

**FACTORS RELATED TO MATHEMATICS ACHIEVEMENT OF
SECONDARY SCHOOL PUPILS**

by

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DECLARATION

I declare that FACTORS RELATED TO MATHEMATICS ACHIEVEMENT
OF SECONDARY SCHOOL PUPILS is my own work and that all the
sources I have used or quoted have been indicated and
acknowledged by means of complete references.

H J Moyana.....

SIGNATURE

(MR H J MOYANA)

30-11-96
.....

DATE

DEDICATION

This study is dedicated to my daughter (Vutivi) and son (Nhlahla).

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SUMMARY

This study investigated the relationships between diverse variables and secondary school pupils' Mathematics achievement. It also dealt with the relative contribution of each variable to Mathematics achievement and the significance of differences in Mathematics achievements when pupils' gender and home background as well as teachers' experience, gender, education, in-service education, homework assignment and testing frequency are taken into account.

A questionnaire was administered on 163 standard 8 pupils. The most important findings of this study were: (1) There was a significant relationship between pupil variables and Mathematics achievement. (2) Pupil variables, particularly self-concept, contributed significantly towards the variance in Mathematics achievement. (3) Pupils who wrote tests often (more than once per term) achieved significantly less than students who wrote tests less often.

KEY TERMS

Mathematics achievement; Secondary school pupils;
Self-concept; Attitudes; Gender-stereotypes; Teachers'
experience; Teachers' qualifications; In-service
education; Study methods; Testing frequency; Homework;
Teachers' gender; Pupils' gender; Socio-economic
background.

CHAPTER 1: THE RESEARCH PROBLEM: STATEMENT AND DEFINITION OF CONCEPTS

1.1 Introduction

From the Department of Education's call, both at national and provincial levels, and the incentives made accessible to students pursuing Mathematics-related studies, it goes without saying that the government envisages a human resources scenario geared towards serving the increasing industrialisation of South Africa. Many colleges of education have been mandated to set up bridging programmes where Mathematics is one of the target subjects.

Furthermore, democracy dictates that a country's human resources should be representative of both sexes. Therefore, South Africa with her newly established democracy needs to address the existing gender imbalances in all Mathematics-related sectors, inter alia engineering, technology, commerce, etc. as a matter of urgency for her to be duly called a democratic country. In fact, Hensel (1989:646) put it succinctly a few years ago when he said: "In an age when equality of the sexes is a popular issue, it is disturbing to note that sex differences in Mathematics learning and achievement still exist. The low representation of women in scientific and

technological fields, the number of women who avoid the study of Mathematics and the available statistics showing general male superiority in Mathematics achievement have created much controversy among those who attempt to explain these phenomena." Fennema, Peterson, and Carpenter (1990:55) align themselves with this assertion by saying that gender differences in outcomes of Mathematics education constitute a pervasive educational inequity that manifests itself in superior performance by boys in high cognitive level Mathematics tasks, in negative personal belief systems about Mathematics by girls, and in under-participation of females in Mathematics-related careers. But for the disparity to be effectively addressed, a very strong mathematical background is warranted on the side of pupils of both sexes. Otherwise, the Government's vision and aspiration to attain modern technological development may be frustrated and the image of the newly acquired democracy will be eroded in its infancy.

It becomes evident from the preceding assertions about Mathematics that the importance of Mathematics in any society cannot be overemphasised. Meece, Wigfield and Eccles (1990:60) said: "A strong background in Mathematics is critical for many career and job opportunities in today's increasingly technological society", like South Africa. In his attempt to show how important Mathematics

is, Georgewill (1990:380) asserted that: "It has ... promoted the growth of many cultures. Mathematics is called 'the queen of all sciences.' It is not only this but it is also the art of all arts. It is regarded as the mirror of civilisation and the emperor of the whole academic world. Opinions from various schools of thought have described Mathematics as the cornerstone from which all other subjects - chemistry, physics, biology, economics - can be built. Mathematics forms the bedrock for other disciplines such as engineering, medicine, agriculture, architecture, etc. Progress in the arms industry, space exploration and guided-missile technology would not have been possible without adequate knowledge of Mathematics."

According to Sells (Strauss 1988:533) and Leder and Gunstone (Ethington 1990:105) Mathematics is widely recognised as a critical filter to a broad range of trades, occupations, tertiary courses and hence to long term career and occupational opportunities. Therefore, Mathematics, as a 'critical filter', could limit the range of career choices available to those who do not do it up to standard ten. This notion is also agreed upon by Bosker and Dekkers (1994:179). But despite the decisive role Mathematics plays in a country's technological welfare, a profession in Mathematics or science has come to be viewed as a prerogative, not of the masses, but of an

intellectual elite. For most people, science and Mathematics beyond the most rudimentary levels are the pursuits of a gifted minority (House 1988:634).

Technological development cannot be a reality unless factors related to poor Mathematics achievement are identified and feasible intervention programmes are sought to remedy discontinuance of mathematical education by academically capable students at secondary schools. Furthermore, poor Mathematics achievement by those who persist on continuing their Mathematics education, as cited by Maqsdud and Khalique (1991:377), should be remedied as well.

The main objective of this study is, therefore, to explore some of the factors related to Mathematics achievement in order to make recommendations for improvement in this area of contention.

1.2 Analysis of the Problem

1.2.1 Awareness of the Problem

South Africa, being a developing nation, is looking forward to attaining self-sufficiency in science and technology. With Mathematics being the foundation subject

for most sciences and technical subjects, technological advancement is integral to Mathematics education (Chacko 1989:64). Steen (1987:251) refers to Mathematics education as a crucial predictor and indicator of future national strength in science as well as technology and economic competitiveness. According to Leder and Jones (1989:77), without Mathematics background, students find it difficult to enter tertiary level courses in Mathematics and related disciplines like engineering.

The rising failure rates and underrepresentation of females have been observed as indicated in Table 1. This could be true to the general South African scenario, but yet to be substantiated through research.

TABLE 1

ANALYSIS OF MATHEMATICS STANDARD 10 RESULTS FOR NOVEMBER 1991, 1992 AND 1993 IN MALAMULELE(NORTHERN PROVINCE)

YEAR	1991						1992						1993					
SCHOOL	No.of F's Wrote	No.of M's Wrote	% Passed		% Failed		No.of F's Wrote	No.of M's Wrote	% Passed		% Failed		No.of F's Wrote	No.of M's Wrote	% Passed		% Failed	
			F	M	F	M			F	M	F	M			F	M	F	M
A	3	9	0	22	100	78	2	11	0	45.5	100	54.5	--	11	--	63.6	--	36.4
B	5	10	0	20	100	80	3	10	33.3	40	66.7	60	10	10	30	20	70	80
C	10	23	50	73.9	50	26.1	17	34	17.6	58.8	82.4	41.2	22	45	9	13.3	91	86.7
D	--	--	--	--	--	--	8	13	0	15.4	100	84.6	13	15	15.4	40	84.6	60
E	9	15	11.1	53.3	88.9	46.7	18	31	5.6	29	94.4	71	18	18	22.2	22.2	77.8	77.8

* Schools have been kept anonymous for reasons of confidentiality.

* School D had its first standard 10 pupils in 1992.

* The letter 'F' is for Female and 'M' for Male.

TABLE 2

ANALYSIS OF MATHEMATICS STANDARDS 6, 7, 8, AND 9 RESULTS NOVEMBER 1993 FINAL EXAMINATIONS.

MALAMULELE WEST CIRCUIT

STANDARD	6					7					8					9				
	NO.	NO	NO	%	%	NO	NO	NO	%	%	NO	NO	NO	%	%	NO	NO	NO	%	%
SCHOOL	WROTE	PASS	FAIL	PASS	FAIL	WROTE	PASS	FAIL	PASS	FAIL	WROTE	PASS	FAIL	PASS	FAIL	WROTE	PASS	FAIL	PASS	FAIL
A	164	91	73	55.5	44.5	155	28	127	18.0	82.0	89	14	75	15.7	84.3	-	-	-	-	-
B	90	63	27	70.0	30.0	76	21	55	27.6	72.4	103	9	94	8.7	91.4	-	-	-	-	-
C	306	107	199	34.9	65.1	261	85	176	32.6	67.4	221	49	172	22.2	77.8	-	-	-	-	-
D	32	22	10	68.8	31.3	-	-	-	-	-	125	20	105	16.0	84.0	30	14	16	46.7	53.3
E	143	59	84	41.2	58.7	89	46	43	51.7	48.3	133	60	73	45.1	54.9	19	18	1	94.7	5.3
F	419	134	285	31.9	68.1	320	3	317	0.9	99.1	139	47	92	33.8	66.2	86	7	79	8.1	91.9
G	457	190	267	41.6	58.4	307	11	296	3.6	96.4	80	21	59	26.4	73.6	17	10	7	58.8	41.2
TOTALS	1611	666	945	41.3	58.7	1208	194	1014	16.1	83.9	890	281	609	31.6	68.4	152	49	103	32.2	67.8

* Schools have been kept anonymous on grounds of confidentiality.

TABLE 3

OVERALL STANDARD 10 MATHEMATICS RESULTS FOR THE PAST THREE YEARS IN MALAMULELE WEST, EAST AND CENTRAL

YEAR	NO WROTE	NO PASS	NO FAIL	% PASS	% FAIL
1990	520	16	459	11.7	88.3
1992	617	113	504	18.3	81.7
1993	524	108	416	20.6	79.4

It is evident from Table 1 that some schools have obtained 100% female failure rate and that a negligible number of females enrol for Mathematics. Klebanov and Brooks-Gunn (1992:97) stressed that the ramifications of these early educational choices have significant implications for life-span decisions ~ from further course taking and a college major to career choice and future employment opportunities for women in an increasingly quantitative and technology based society. It is further noted that the general pass rate is also not satisfactory as can be seen from Table 3. For example, in 1993, 79.4% of the pupils failed.

It is against this background that the researcher feels that the nation's urgent efforts towards technological

take-off will be affected drastically unless the high failure rate in Mathematics is reversed without delay. This sentiment is shared by the Government as well as evidenced by the channelling of funds to alleviate this poor performance in Mathematics and science, for setting up bridging programmes at a number of tertiary institutions to help those who did not do well in Mathematics and science in standard 10.

The writer learnt from experience as a Mathematics teacher both at secondary school level and in the bridging programmes set up at colleges of education that "students regard Mathematics as a jig-saw puzzle and something baffling." In his address at the Annual Congress of South African Mathematical Society, Webb (Maqsud & Khalique 1991:377) stated that to the general public, Mathematics is a subject to be avoided and ignorance of the subject is often a point of pride. This is in keeping with the researcher's observations. This is further explicit from Tables 2 and 3, provided by the Malamulele Mathematics Advisory Office (Northern Province), that pupils' performance is generally not satisfactory. In Table 2 (in schools A, B and C) all students discontinued their Mathematics education because it was not compulsory after standard 8.

Another point of concern of the researcher is the

negligible number of females participating both at secondary school level and in the bridging programmes. This is evident from Table 1. Many females discontinue to study Mathematics as soon as an option is available. Furthermore, even those who continue their Mathematics education do not perform satisfactorily as can be seen from the fact that some schools have obtained 100% female failure rate at times. Cramer and Oshima (1992:18-19) said that despite recent attempts to increase the participation of women in advanced educational training and high-status professional occupations, females in general are still underrepresented in many occupational and educational settings compared to their male counterparts. They further reported that a lower percentage of females enter careers in science, engineering, and related professions compared to males. This is supported by Smith and Gessler (1989:33) in their survey of engineering students in the USA when they said: "Our typical engineering freshman is young, male, ... and middle class. ... The percentage of male students was 85, indicating that female students still are not seeing engineering as a viable career option." Cramer and Oshima claim that this is at least partially linked with insufficient Mathematics education.

Researchers such as Boling (1991:18) and Cramer and Oshima (1992:19) are among those who presented well-documented

evidence that this variability in Mathematics achievement among students in general and between sexes start coming to light during early adolescence. In support of this assertion, when studying Table 2, it is noted that many standard 6 pupils (mostly pre-adolescents) perform relatively better than those in standards 7, 8 and 9. This is shown by the relatively high pass rate at standard 6 level. It is also clear that a very sharp decline in Mathematics performance starts in standard 7 (when most pupils enter the adolescent stage). Note also that in schools A, B and C all students discontinued their study of Mathematics because it stops to be compulsory from standard 9.

This is a timely study as our nation is moving into a globally integrated society "requiring increased skill development for everyone in advanced Mathematics and the mathematically-related disciplines" (Iben 1991:135).

1.2.2 Examination of the Problem - Some Comparisons to other Countries

This problem manifests itself in quite a number of forms - ranging from (a) poor general Mathematics achievement to (b) lack of females studying Mathematics.

A similar study in Australia by Rowe (1988:180) contended that: "... despite continued improvements in students retention rates at the upper levels of post-primary schooling ... , the majority of girls in Australian schools choose not to take Mathematics and science subjects at these levels." Steen (1987:251) established that despite the widespread utility of Mathematics in industrial, military, and scientific applications, the Mathematics yield of U.S. schools is substantially less than that of other industrialised nations. Steen further reported that levels of achievement in the United States are unacceptably low. This trend can be attributed to prior poor performance or the type of socialisation students in general, and girls in particular receive from their significant others like parents, teachers, and peers.

In South Africa, policy-makers and educationalists alike, are aware of the importance of Mathematics in the development of the nation. This is explicit in the educational policies that stress satisfactory Mathematics achievements at all levels of educational institutions as well as the admission requirements to higher/tertiary institutions of learning. All the same, the performance of the students in Mathematics at the ordinary level examinations conducted at the end of every year of secondary schooling is unsatisfactory. The picture of the

extent of the severity of this problem can be seen in Tables 1 and 3 provided by the Malamulele Mathematics Advisory Office (Northern Province) showing the overall results for the years 1990 to 1993. This trend was also found by Chacko (1989:64) in his study in Nigeria.

It is clear from Tables 1 and 3 how alarming the Mathematics failure rate is. Though there is an increase in pass rates from 1990 to 1993 (refer to Table 3); the improvement cannot be considered to be very encouraging.

According to Mayer (Smith 1989:219); the economic health of a nation with poor student achievement in Mathematics is doomed. Steen (1987:251) referred to Mathematics as the foundation discipline for science. He further claimed that Mathematics education is a crucial indicator of future national strength in science and technology and economic competitiveness. This is because it is undoubtedly true that a strong mathematical background is necessary for many career and job opportunities in an increasingly technological society like South Africa (Maqsdud & Khalique 1991:377).

In their account of The Algebra Project's mission and history, Silva and Moses (Kamii 1990:392) argued that mathematical literacy is fast becoming a prerequisite not only for participation in a global economy driven by

technological change, but for citizen participation itself. They also warned that communities whose members are lacking in mathematical literacy risk becoming "a permanent underclass who, generation after generation, live on the margins of the nations' economic and political institutions."

Mudeliar (1987:1) put it in a rather appealing language when she said: "Mathematics in one form or another is being applied to an increasing number of disciplines. It is generally accepted that the study of Mathematics is important in the education of those who wish to make their mark in today's technological world." This notion holds water given the fact that the twentieth century brought with it an ever-increasing sophistication in science and engineering; hence the relevance of Mathematics is greater than ever before. In fact, Steen (1988:88) refers to Mathematics as "a key predictor of scientific competitiveness."

Research evidence shows that in most West-European countries girls recently managed to be on par with boys in the achieved level of education. Still, girls and boys differ in that girls are underrepresented in technical and science fields (Bosker & Dekkers 1994:179).

Kamii (1990:392) asserted that traditionally, national

concern about the severe underrepresentation of women in mathematically based careers has focused on issues of equity, but the current sense of urgency stems from projections of twenty-first century demographic and economic realities. He further warned that if the U.S. is to maintain standards of excellence and leadership in the twenty-first century, then it must find ways to attract and educate underrepresented peoples in the fields of Mathematics, science, and engineering.

This is a strong warning for a developing country like South Africa. The underrepresentation of females in Mathematics education and mathematically related careers as observed by a number of researchers in South Africa, inter alia, Cherian (1993:772) is accounted for by poor Mathematics background and achievement. This might have deprived our females of the right to further their studies along these streams. It also supports Strauss' (1988:533) and Leder and Jones (1990:106) statement that Mathematics is really a 'critical filter'.

From the foregoing documented trends on Mathematics achievement and other research articles reviewed by the researcher, it is worrying to face the reality that quite a negligible number of studies, if not none, are on the South African context. This study is, therefore, intended to contribute to the literature by providing evidence for

a South African context regarding factors related to Mathematics achievement.

1.3 Statement of the Problem

From the assertions above about the importance of Mathematics in today's technological world and the prevailing poor achievement in Mathematics achievement, it appears to have become expedient for a study to be conducted in the South African context to identify factors that have been internationally documented related to Mathematics achievement. The factors' relationship to Mathematics achievement must be established and recommendations made on how the poor achievement can be improved.

The problem is, therefore, to establish if there are factors significantly related to achievement in secondary school Mathematics. Hence, the specific research problem is as follows:

Which factors are significantly related to Mathematics achievement of secondary school pupils?

1.4 Aims of the Study

1.4.1 Specific Aims

The current study attempts to investigate the relationship between certain factors (which will be identified by means of a literature study) on the one hand and Mathematics achievement of secondary school pupils on the other.

Therefore, the study will attempt to answer the research problem as stated in 1.3.

1.4.2 General Aims

Hardly a study has been conducted in the South African context in general, and in Shingwedzi-Levubu (Northern Province) in particular, regarding factors related to Mathematics achievement of secondary school pupils. So, in general, the purpose of this study is to form a basis on which the improvement of Mathematics education in our country can be based. Through the recommendations and suggestions in this study, policy-makers and educationists will have a springboard from which they can move towards saving our country from the economic doom. This is likely to unfold unless some intervention programmes are put into practice to remedy the prevailing poor Mathematics achievement in our country.

The specific and general aims are achieved by two methods:
A literature survey (chapters two and three) and an
empirical investigation (chapter four).

1.5 Demarcation of the Field of Study

This research attempts to investigate if there are factors which are significantly related to secondary school pupils' Mathematics achievement. It needs to be pointed out, however, that this study will not establish causal relationships. The method of research is *ex post facto*, and will determine correlations.

1.6 Definition of Concepts

1.6.1 Factors

Oxford Advanced Learners' Dictionary of Current English defines factor as "fact, circumstance, etc, that helps to produce a result." Longman Dictionary of Contemporary English refers to factor as "any of the forces, conditions, influences, etc, that act with others to bring about a result." Reber (1985:265) defined factor as "generally, anything that has some causal influence, some

effect on a phenomenon. In this sense a factor is an antecedent condition, a cause."

Therefore, for the purpose of this study, factors will mean circumstances, conditions, influences, etc, that have some effect on Mathematics achievement of secondary school pupils. These factors are considered as independent variables for the purpose of this research.

1.6.2 Mathematics Achievement

Achievement has been defined in many ways. Van den Aardweg and Van den Aardweg (1988:8) defined achievement as "a product which can be measured by means of achievement tests. Achievement is ... associated with mental success..." Reber (1985:5) explained achievement as "accomplishment or the attaining of a goal." But this study will adopt Oxford Advanced Learners' Dictionary of Current English which regards achievement as success "gained by effort and skill." Therefore, for the purpose of this study, Mathematics achievement will mean the performance of pupils in Mathematics as determined by the magnitude of scores gained in Mathematics tests and

examinations.

1.6.3 Secondary School Pupil

According to Van den Aardweg and Van den Aardweg (1988:204-205) "After primary school years the child enters the secondary school. The junior secondary school usually runs from standard 5 to standard 7 and the senior secondary school from standard 8 to standard 10. In some instances, this is the theoretical position but in practice the secondary school caters for standards 6 to 10 (approximately 13 - 18 years of age)." This study aligns with the latter position since our population is obtained from schools where secondary schools cater for standards 6 to 10. Particular attention will be given to pupils still at junior secondary school level, i.e. standards 6 to 8. Researchers such as Reynolds (1991:133), Georgewill (1990:379) and Boling (1991:18) have reported well-documented evidence that factors related to the affective domain, like attitudes towards Mathematics, and disparities in boys' and girls' achievement in Mathematics start with the onset of adolescence from 12 to 14 years of age.

The following are the facets of adolescence:

1.6.3.1 Adolescence and the Adolescent

Bootzin, Bower and Crocker (1991:470) referred to adolescence as the period during which young people move out of childhood and get ready to take up their adult lives. During this stage, girls and boys develop physical characteristics of adults, they begin to think like adults and they also start assuming adult privileges and responsibilities.

According to Klebanov and Brooks-Gunn (1992:82), during this stage of development, the adolescent is confronted with a plethora of intertwined and complex challenges such as the accommodation of pubertal changes, the regulation of moods, the alteration of childhood ties to parents, the management of opposite sex relations, the reorganisation of self-definitions, and the acquisition of new academic and work-related skills and interests. This is the reason why Louw (1991:377) defined adolescence as "the developmental stage between childhood and adulthood." He further indicated that the term "adolescence" is derived from the Latin verb 'adolescere', which means "to grow up" or "to grow to adulthood."

Adolescence is a period during which young people get out of childhood and get prepared to take up adult responsibilities. Due to individual and cultural differences, the age at which adolescence begins differs from 11 to 13 and the age at which it ends varies from 17 to 21 (Louw 1991:377). It is a period during which adolescents experience physical, psychological and social changes (Bootzin et al 1991:470). Louw (1991:377) went on to indicate that "adolescence begins during puberty - i.e. when rapid physical growth begins, the reproduction organs begin to function, sexual maturity is reached and secondary sexual characteristics appear."

According to Steinber (Bootzin et al 1991:470) and Papalia and Olds (1993:483), the period of adolescence is divided into three subphases: Early adolescence, from eleven through fourteen, roughly corresponding to the junior secondary school years; middle adolescence, from fifteen through eighteen, roughly corresponding to the high school years; and late adolescence (or youth) from nineteen through twenty-one, roughly corresponding to the tertiary level.

In South African Black communities where traditions are still firmly entrenched (more especially in rural areas), the period is marked by ceremonial rites. Girls are kept in huts for weeks or even months receiving intensive

training, and boys have to complete prescribed initiation rites (in circumcision schools) (Louw 1991:378; Mwamwenda 1994:45).

Because of today's lifestyle which demands years of educational training, the late adolescent stage is stretched to about 23 years. This gives the developing adolescent enough time for self-identity search. This is what Erikson calls a "psychosocial moratorium", i.e. the period of high school and college, when most people are still free from adult roles and responsibilities (Bootzin et al 1991:476; Louw 1991:441).

The focal period of adolescence for the purpose of this study is early adolescence. This stage of adolescence has been chosen for this purpose because many researchers inter alia Xu and Farrel (1992:442) and Bower (1986:357) contended that this is the period where all the problems related to Mathematics achievement start coming to light.

1.6.3.2 Developmental Aspects of Adolescence

* Cognitive Development

According to Piaget (Papalia & Olds 1993:515), Louw (1991:400 - 402) and Papalia, Olds and Feldman (1989:360) adolescence is the time when many people reach the highest

level of intellectual development which they call formal operations. This stage is characterised by the ability to think abstractly (i.e. to think not only about "is" or the "here and now" but also about what "can or may be") and to deal with logical possibilities. During this stage the adolescent has the mental capacity to combine and separate variables in a hypothetical-deductive framework (Rice 1992:208). This is why Louw (1991:400) referred to adolescence as the "time of the dreamer" and the time during which theories are constructed - a period at which the adolescents think about reality and abstract things and at which a world of possibilities opens before them.

It must be pointed out, however, that some adolescents never attain this formal operational stage. This is due to limited intelligence, cultural deprivation or environments that are so poor that cognitive development is not well nurtured (Mwamwenda 1994:68; Louw 1991:408).

In brief, according to Piaget (Rice 1992:209) the formal operations stage involves three major aspects:

(1) introspection (thinking about thought), (2) abstract thinking (being able to consider all important facts and ideas and to form correct conclusions, such as the ability to determine cause and effect), and (3) hypothetical reasoning (formulating hypotheses and examining the evidence for them, considering numerous variables).

This is therefore a timely period for the purpose of this study because the adolescent could be considered to be mentally well-developed to cope with the Mathematics content at secondary school level.

* Affective Development

There are many emotions that adolescents experience as they relate to their parents, their teachers and society at large. These emotions can be aggressive and inhibitory (e.g. fear, anxiety and worry) or joyous in nature (Mwamwenda 1994:50).

During early adolescence both boys and girls worry about their school work and examinations. Girls worry more than boys about performing satisfactorily at school. This might account for the poor performance by girls in Mathematics, and eventually, a greater dropout rate. Nevertheless, others are delighted about their success at school, which provides them with a sense of achievement (Mwamwenda 1994:50).

Other emotions that adolescents experience as they relate to their significant others are anger, love, hate, disgust, desire for honour and recognition, curiosity, humiliation and embarrassment. Some of these emotions that

develop during early adolescence (like interest, confidence, positive attitudes towards Mathematics, curiosity, etc.) enhance learning in general, and Mathematics achievement in particular. Some of these emotions, however, impede learning, for instance emotions like anxiety, worry, fear, etc. Hence the need to establish whether some of these affective domain aspects are related to Mathematics achievement or not.

* Social Development

According to Klebanov and Brooks-Gunn (1992:86), during adolescence conflict between parents and children increases. They further maintained that many researchers attributed this conflict to the adolescent's increased need for autonomy which actually results in a renegotiation of the parent-child relationships - from a more unilateral to a more mutually acceptable relationship. They also claimed that adolescents who have poor relationships with their parents have been found to have lower grades in general, and exhibit more behavioural problems than their peers with better parental relationships. During this stage of development, adolescents experience a constant tension to break away from their parents and their reliance on the parents (Papalia & Olds 1993:547). This is due to the changes adolescents go through: They need people who face

problems like theirs so that they can take comfort in them. They want to become emotionally bound to others who share their vulnerabilities and their deepest feelings (Rice 1992:429). This is in line with the maxim "misery loves company" (Naude & Bodibe 1990:109).

Since preference shifts from parents to the peer group during this stage, for the adolescent to be accepted by the peer group she/he has to conform to their expectations and influences. The peer group sets the criteria by which the adolescent's status in the group is determined. These criteria are often different from those that apply in the adult world. Apart from setting the criteria for determining status, the adolescent's peers also act as a reference group which gives the adolescent the opportunity to assess his own behaviour, problems, needs and goals (Louw 1991:419). Conformity with peers is shown in dress, hairstyles (perming), tastes, vocabulary and adornment, and gives the adolescent a sense of belonging (Mwamwenda 1994:45). This, however, may also influence his motivation to achieve inter alia in Mathematics.

Thus, it is necessary to explore some of the factors related to the peer group that might be related to Mathematics achievement of the pupil at this age. This is because given the influential role the peer group play on the adolescent's life, they might be very influential on

the pupils' achievement with regard to Mathematics.

* The Adolescent and Identity Formation

As adolescents develop cognitive skills that make deeper analysis of their world possible, s(he) begins to turn these skills on the subject closest at hand - the self. Adolescents start to ask questions such as "Who am I?" "What should I do with my life?" "What does it mean to be an adult?" "What do I believe in?" (Papalia & Olds 1993:475). The search for one's identity becomes a preoccupation. This search is what Louw (1991:440) referred to as identity formation.

The adolescent wants to know who s(he) is, what s(he) is capable of achieving, what s(he) wants to do in her/his life, what values he/she wants to adopt as their own, who she/he wants to marry, the kind of family she/he wants to have, and whether he/she is sex appropriate and capable of sustaining friendships and commanding the respect of others.

The peer group helps clarify some aspects of the adolescent's identity (Mwamwenda 1994:48). The parents are also very important for the adolescent during this trying period to provide comfort and confidence to carry on. Louw (1991:446) pointed out that "adolescents' identity

formation is facilitated by the rewarding and caring behaviour of their parents, by the parent of the same sex being an effective personal and social role model, and by the parent of the opposite sex being an effective parental model and approving of the role model of the same-sex parent."

It is clear that answers to the questions cited above provide self-definition to the adolescent. That is why, according to Erikson, an identity crisis occurs during adolescence, since the adolescent is engaged in redefining himself and his role in society (Louw 1991:440). As the adolescent tries to seek answers to these questions, s(he) explores interests and belief systems. Since careers of today require extensive education and most families are affluent enough to keep their children at school, adolescents have enough time to search for answers to the afore-mentioned questions - which Erikson calls "psychosocial moratorium" (Papalia & Olds 1993:476).

By seeking answers to these questions, the teenagers are in the process of identity formation - effort to make sense of the self. This search for identity enables the adolescent to know what s(he) is good at. For instance, their ability in Mathematics. Knowledge of possible occupation enables the adolescent to strengthen the background of prerequisite school subjects. For example,

if the adolescent intends to be a computer scientist, s(he) will strengthen their mathematical background.

According to Roazen (Louw 1991:446-447), the individual who has successfully resolved his identity crisis is characterised by:

- tolerance towards the self and other people
- the ability to make decisions and to complete tasks
- the realisation of his abilities in his career
- the courage to be alone and independent
- a future perspective and the ability to cope with new realities and conflicts
- the ability to be fully human.

However, failure to emerge with a well-defined identity results in what Erikson calls identity confusion. This state of identity confusion is characterised by inability to choose a role or make commitments in life - such as a commitment towards the study of Mathematics (Naude & Bodibe 1990:25).

1.7 Programme of Study

In chapter two, the literature review on the factors related to teachers and to the pupils' home environments, and how these in turn are related to Mathematics

achievement are, given.

In chapter three, a review of the literature on the peer group and pupil variables, and how these are related to achievement in Mathematics, are provided.

Chapter four describes the research design.

In chapter five, the results based on the data collected are presented and discussed.

In chapter six, conclusions and recommendations are made.

CHAPTER 2: TEACHER AND PARENT VARIABLES AND MATHEMATICS ACHIEVEMENT

2.1 Introduction

As explained in the previous chapter, Mathematics is a pillar of almost all the career streams and the academic sector. Given the key role Mathematics plays in tertiary education and in most vocations, Mathematics has come to be an area of concern among both parents and teachers because of the prevailing poor achievement by pupils in this subject area.

In her review of the literature, Mudeliar (1987:3) concluded that relating to mathematical ability and interest, attitudes are developed in the home, in some instances before the child begins school. Parents who have been negatively conditioned towards Mathematics by both their parents and by school in turn transfer these feelings to their children. Klebanov and Brooks-Gunn (1992:97) pointed out that parents as well as teachers are important socialisers of attitudes.

Parents mostly blame teachers of being incompetent and teachers blame parents for not motivating children positively with regard to schoolwork in general and

Mathematics in particular. But how greatly are both of them related to pupils' Mathematics achievement?

In this chapter, teacher and parent variables and their relationships with Mathematics achievement are discussed.

2.2 Factors Related to Mathematics Achievement of Secondary School Pupils

2.2.1 Factors Related to the Teacher

2.2.1.1 Introduction

Teachers are key figures in improving mathematics achievement (Mullis 1991:212). In a study of teaching-method scales, Hafner (1993:72) established a general relationship between teacher behaviour and student achievement. Given this background about the importance of the teacher in learning, it appears to be necessary to establish statistical relationships between some of the teacher variables and pupils' achievement in mathematics. Are teachers experienced? Are they well educated? Do they keep up with current Mathematics content and educational practices? These and other aspects are discussed.

2.2.1.2 Teachers' Attitudes

According to Allport (Van den Aardweg & Van den Aardweg 1988:26; Maqsdud & Khalique 1991:386), "An attitude is a mental or neural state of readiness, organised through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related." Attitudes prepare people for action, are learned from experience and exert a motivating force on behaviour. Norwich and Rovoli (1993:309) defined attitudes as "the outcome of a person's beliefs about the outcomes of the behaviour and his or her evaluations of those outcomes..." In the context of this study, teachers' attitudes towards Mathematics means the teachers' mental state of readiness and their behaviour in relation to Mathematics, organised through experience with Mathematics.

According to Tocci and Engelhard (1991:280), attitudes of the students are developed by direct experiences with the attitude object and by interactions with the relevant others like teachers. They further contended that interactions with other persons provide individuals with information in the form of attitudes, beliefs, and behaviour of important others, that becomes a guide for the development of their own attitudes. This shows how the significant others like teachers can help shape pupils'

attitudes.

Attitudes:

* towards Mathematics

Taylor (Tooke 1993:274) found a strong relationship between teacher attitude towards Mathematics problem solving and pupil achievement. Midgley, Feldlaufer and Eccles (1989:248) argued that at junior secondary school level, pupils have a number of teachers each day. Therefore, it may take time for the beliefs and attitudes of one teacher, such as the Mathematics teacher, to have an effect on students' beliefs and attitudes in Mathematics.

Mudeliar (1987:4) also asserted that teachers' attitudes towards Mathematics have a strong bearing on students' attitudes and achievement in Mathematics. In a review of the literature on students' attitudes to Mathematics, Dungan and Thurlow (1989:10) concluded that students' attitudes to Mathematics are derived from teachers' attitudes to this subject. This in turn impinges on students' Mathematics achievement.

* towards the pupils

Not only attitude towards the subject, but also attitude towards the pupils, influence pupils' attitudes towards Mathematics. Chen, Clark and Schaffer (1988:116) established in their literature review that teachers positively influence learning and achievement through high expectations in relation to student learning. Cheung (1988:316) and Sayers (1994:397-399) found that if a pupil believes that a teacher has a low opinion of her/him, then it is possible that the pupil will perform according to that expectation.

* towards gender roles

Teacher's attitudes towards gender roles have also been cited as responsible for gender stereotypic behaviour with regard to Mathematics learning. In their interaction with pupils in class, teachers display subtle and mostly unconscious differential treatment of the sexes and expectations of sex-related differences in achievement (Hensel 1989:650). These differential teacher expectations for boys to excel in Mathematics contribute greatly to observed sex differences in cognitive achievement (Randal 1990:619). The gender biased, unconscientious teacher attitudes end up self-fulfilling prophecies about their students, resulting in boys excelling and girls achieving

poorly in Mathematics.

According to Warwick and Jatoi (1994:395-396) students with a male teacher have significantly higher achievement means than those taught by female teachers. Sayers (1994:400) reported in a study of gender differences in Zambia that for pupils with male teachers, there were marked differences in the attitudes of boys and girls towards Mathematics. He further maintained that the presence of a female Mathematics teacher was strongly associated with a reduction in attitude differences between boys and girls. He went on to say that differences in girls' attitudes from boys' in terms of confidence, anxiety, enjoyment and perception of utility are more marked in classes taught by male teachers. This can be attributed to male teachers' differential gender expectations in favour of boys.

2.2.1.3 Teachers' Competence

* Education

For the purpose of this study, teachers' education means the amount of education, both academic and professional, a teacher received in Mathematics.

Amongst other researchers, Georgewill (1990:383) concluded

in his review of the literature that professional education is necessary, particularly for secondary school teachers in their special fields like Mathematics. He further observed that while accepting that teachers are born and not made, it is true that education will make a born teacher better. Education enables teachers to better understand the thought processes of the learner, and to know specific skills and attitudes to emphasise in teaching the students.

For instance, Vatter (1992:292) suggested that we can help at-risk students find some success if (1) schoolwork is hands-on, (2) students' feelings of worth and accomplishment are nurtured by the work itself, and (3) the work is tied to real work in the real world. This suggestion can only be effectively implemented by a professionally qualified teacher who knows and understands pupils' thought processes, and not by poorly qualified teachers who slavishly stick to the textbook. Leder and Gunstone (Ethington 1990:109) referred to Colburn who recommended that the textbook should not be followed slavishly, but should be adapted to suit the needs of both the teacher and pupil. Only teachers well versed with their own subject matter would be capable of the flexibility required to implement this recommendation.

There are a number of factors that lead to low achievement

by learners, in the Northern Province in particular. From the researcher's point of view, one of those factors is that many teachers are poorly educated - both in the subject as well as with regard to professionalism. This factor is not unique in the Northern Province. Lockheed and Komenan (1989:94) observed that there is a consistent positive relationship between formal educational attainment of teachers and students' achievement.

Contrary to Lockheed and Komenan, Maqsd and Khalique (1991:379) noted that in spite of the availability of well qualified Mathematics teachers in some Bophuthatswana (now the North-West Province) schools, the matriculation results of such schools remain far below the acceptable standards. However, Bracey (1991:86) also attributed Japan's leading Mathematics achievement to better educated teachers. One reason for this is cited by Ethington (1990:106). He said that low educational background of teachers promotes a strict adherence to the textbook content. This is condemned by Schmalz (1990:16) when she says the textbook must not be "the sole determiner of our daily Mathematics instruction. Let us be bold enough to restructure the order and development of the topics without apology. In this way, the textbook becomes a servant and not a dictator."

Tooke (1993:274-276) also reported a significant relationship between teacher educational background and student achievement. House (1988:638) asserted that education is a partnership, and we won't develop successful students without also developing successful teachers.

* Confidence

The Oxford Advanced Learners' Dictionary of Current English defines confidence as a "belief that one is able to do something". Thus, in this study, teacher confidence means the belief that he/she is an able Mathematics teacher.

Taylor (Tooke 1993:274) reported that if teachers display confidence with their content, a positive relationship between teacher knowledge and student achievement can be hypothesised. Chen et al (1988:116) also stated that there is a significant relationship between a teacher's confident responses to students' questions and performance on tests. According to Midgley et al (1989:256) teachers who do not feel confident about their knowledge of Mathematics content are likely to communicate low expectations. Hence, pupils achieve poorly. They further maintained that teachers who have confidence in themselves as Mathematics teachers are more effective. This also

shapes pupils' positive perceptions of their teachers' ability to help them learn the subject matter more effectively.

* Experience

The Oxford Advanced Learners' Dictionary of Current English defines experience as "knowledge or skill ... gained by doing and seeing things." Therefore, in this research, teacher experience refers to the number of years of teaching Mathematics.

Lockheed and Komenan (1989:105) documented a significant positive relationship between teacher experience and student achievement in some developing countries, for example Nigeria and Swaziland. However, Chen et al (1988:116) established no significant relationship between teacher experience and pupils' Mathematics achievement. Accordingly, Mullis (1991:385) cited a lack of consistency in relationship between teacher experience and pupils' Mathematics achievement across the USA. Thus, research is inconclusive with regard to the effect of experience on Mathematics achievement.

* In-service Education

Little empirical evidence has been established regarding the influence of in-service education on students' Mathematics achievement. Mullis (1991:224-225) in their assessment of the state of Mathematics achievement in the USA found some modest evidence of a positive relationship between the amount of in-service education and student achievement in grade 8. However, in grade 4, in-service education did not seem to be significantly related to Mathematics achievement. They concluded that in the majority of states, eighth graders whose teachers had more in-service education performed better than those whose teachers reported less in-service education (Mullis 1991:389).

2.2.1.4 Teachers' Methods

According to Bosker, Kremers and Lugthart (1990:244); effective teaching has a positive effect for boys and girls, but this effect is more pronounced for girls. Effective teaching is facilitated by teaching methods. Here teachers' methods are discussed.

* Co-operative Learning

Richards, Platt and Platt (1993:87) regard co-operative learning as "an approach to teaching and learning in which classrooms are organised so that students work in small co-operative teams."

Co-operative learning augurs well with the motto "One for all, and all for one" (Orsak 1990:345). The awakening of an independent spirit in adolescent years and the rise in peer group influence combine to lure students away from earlier bonds to the authority of teachers (Boling 1991:17). At this stage students relate well to one another and less well to authority figures like the teacher. This can impact negatively on students' learning and achievement if teaching takes place in the traditional pen-and-paper classroom setting. This change in socialisation patterns can be made to work for, instead of against, the creative teacher (Boling 1991:18). This can be made possible by using co-operative learning strategies (group-oriented activities) in Mathematics learning and problem-solving.

Stacy (1992:261) maintained that co-operative group work is an increasingly popular strategy for teaching Mathematics. Stacy further maintained that this strategy is very frequently associated with teaching of problem

solving.

Orion and Davidson (1992:257) listed benefits enumerated by group-oriented learning activities to include greater student enjoyment, and improved individualisation by allowing the teacher to attend the needs of a few groups rather than those of many separate students. A number of researchers added to this list of benefits. Hart (1993:170) pointed out that in his study, the challenge and disbelief of peers acted as a form of external monitoring when self-monitoring was not apparent. She further indicated that although students seldom questioned their own strategies, they occasionally did challenge each other. Such encounters seem to force them to examine their own knowledge, strategies, and beliefs more closely.

Hart further asserted that collaborative efforts allow problem solving to continue when an individual member might have encountered an impass. It also provides a less restrictive social environment in which students are more able to pursue various strategies and ideas. Stacy (1992:261) said the reasons given for the use of group work in problem solving includes the opportunity for pooling of ideas, the natural need that arises to explain and express ideas clearly and the reduction in anxiety for tackling something hard.

Courcier and Stephens (1993:712) reported that in co-operative groups, many students develop the ability to work with others as well as develop sensitivity to others' needs and interests. Finn (1990:128) contended that having most or all of one's peers involved in class-related activities, whether they serve as models or as sources of direct reinforcement can be a strong motivator in learning and achievement. Sutton (1992:64) also cited that in addition to developing positive peer relations and interaction, co-operative learning experiences tend to promote higher achievement than do competitive and individualistic learning experiences. Thus, Mullis (1991:300) associated high achievement with more frequent group work in several states in the USA. In some states, poor achievement was found to be associated with more frequent group work whereas in most states, there was no difference in achievement regardless of frequent group work. Schaub and Baker (1991:635) also cited that having students work in small groups lowers achievement.

Abrami, Chambers D'Apollonia and Farrel (1992:207) established a positive relationship between teacher use of co-operative learning strategies and student achievement. In a wide review of literature of research on the effects of co-operative learning, Chambers and Abrami (1991:140) concluded that there is a positive and substantial effect on achievement. Chambers and Abrami (1991:145) went on to

indicate that students low in prior achievement who work in successful teams can benefit academically. However, students low in prior achievement who work in unsuccessful teams are at a disadvantage academically. Webb and Farivar (1994:370) found that students learn more by giving elaborated help to others. Nichols and Miller (1994:167) reported in their literature review that one factor influencing the success of co-operative group instruction is the positive motivational impact of peer support for learning.

It is in the light of the above cited contradictory findings regarding co-operative learning that the researcher feels further clarity is necessary with regard to the relationship between co-operative learning and achievement in Mathematics.

* Instructional Aids

According to Raphael and Wahlstrom (1989:190) instructional aids refer to such manipulatives as rulers, compass, protractors, etc.

Numerous authors plead for the use of concrete teaching aids when teaching Mathematics: Boling (1991:18) argued that teachers need to use concrete materials like hands-on measuring equipment in Mathematics teaching and learning.

She further indicated that what is taught is not as great a problem as how it is taught, hence the need for manipulatives during lessons.

According to Kalejaiya (Georgewill 1990:380), lack of teaching aids militates against Mathematics education. Georgewill (1990:384) further argued that Mathematics teachers in Nigeria relegate to the background the use of teaching aids because of their undying attachment to the traditional 'talk and chalk' method of teaching Mathematics which influenced pupils' Mathematics achievement.

Mullis (1991:300) also contended from their review of the literature that regular use of concrete materials and tools have a significant effect on both student achievement and attitudes towards Mathematics. However, in their own empirical work, Mullis (1991:301) found that in some states eighth graders who reported using teaching aids less than once a week scored better than those who reported frequent use.

* Homework

Homework here is meant the exercises which a teacher gives to pupils to do at home. The frequency of homework given is determined by the number of exercises given to pupils

per week.

According to Turner (Cobb; Peach & Craig 1990:168), homework is assigned to students for a variety of reasons: (1) facilitating learning through practice and application; (2) individualising learning for both slower and more advanced students; (3) completing work not finished during school hours; (4) teaching independent study skills and work habits; and (5) communicating to parents the skills and materials that are taught in class. However, Cobb et al (1990:170) could not find a significant difference in academic achievement when homework was done or not done. Mullis (1991:351) also found that in some states in the USA, students who reported doing more homework had low achievement scores.

On the other hand, Sedlacek (1990:15) reported a significant relationship between daily Mathematics homework and Mathematics achievement. Moodley (Mudeliar 1987:38) also established a positive relationship between homework and Mathematics attainment. Thus, with regard to homework, results seem inconclusive regarding the relationship with Mathematics achievement.

* Content Coverage

Chen et al (1988:116) concluded from reviewing literature that content coverage was related to student achievement. Raphael and Wahlstrom (1989:173) reported strong research evidence to show that achievement in Mathematics was significantly related to topic coverage. Hafner (1993:83) and Lockheed (1990:18) also supported this assertion.

* Testing

According to Kika, McLaughlin and Dixon (1992:159), a large amount of the research on frequency of testing supports the idea of improved outcomes in student performance as the rate of testing increases. Turney (Kika et al 1992:159) found that his students favoured frequent testing. Kika et al (1992:161) found that weekly testing did have a positive effect on the academic performance of high school algebra students. The average increase in class means was found to be 5.5% and 8% for the two groups considered.

There is a common belief at universities or in colleges that frequent, short written tests can: (1) make students concentrate on courses which they are learning; and (2) provide necessary feedback in order for students to improve their learning performance (Ma 1995:17). Johnson

conducted a study on two calculus classes: one calculus class was given short weekly tests while the other class was not given any tests. At the end of the course, students in the first class scored significantly higher than their counterparts did (Ma 1995:17).

In a study of the effect of testing frequency upon the achievement of students in high school Mathematics, Dineen, Taylor and Stephens (1989:200) found that there were no significant differences between test scores of students who were tested weekly and those who wrote tests only at the end of every semester. However, the experimental group (weekly tested group) had higher means on the semester test.

2.2.1.5 Teachers' Personality

Mudeliar (1987:40) claimed that the personality of the teacher, and whether he is liked or disliked by pupils influence the children's attitude and subsequently their achievement. According to Dungan and Thurlow (1989:9), the extent to which students like their teacher influences their liking of the discipline/subject.

Newman and Stevenson (1990:208) reported that low achieving high school students give credit to the teacher

when they do well and blame the teacher when they do poorly. Valas and Sovik (1993:290) documented that students' perception of their teacher as a controlling agent also seem to affect their achievement in Mathematics. Reynolds and Walberg (1992:324) indicated that "... Mathematics attitude ... appears to require qualitative components as reflected by students' perceptions of their teacher's clarity of expression and instructional support. It appears, for example, that students are more likely to acquire favorable attitudes towards Mathematics if they perceive the classroom context (e.g. teachers) in a positive light."

2.2.2 Factors Related to the Home Environment

2.2.2.1 Introduction

The influence the home has on Mathematics achievement has enjoyed as much research attention as any other variable in Mathematics education. Kaiser-Messmer (1993:210) and Campbell and Mandel (1991:71-72) documented that a sizable portion of Mathematics achievement is accounted for by family influences. Marjoribanks (1987:121) concluded that the Mathematics performance of the 11-year-olds of his sample had moderate relations to family environment influences.

According to Dungan and Thurlow (1989:105), parental and home influences may also be significantly relevant to students' attitudes to Mathematics and deciding whether or not to take Mathematics as a core subject of study.

Research findings place a lot of emphasis on parental influences which is said to determine the child's initial attitude, and affects his/her achievement. Where parents themselves used to have trouble with Mathematics, so does the child (Mudeliar 1987:40). With such an influential role, the home environment deserves research attention. Therefore, in the remainder of this chapter, home influences on Mathematics achievement are discussed.

2.2.2.2 Socioeconomic Status and Pupils' Mathematics Achievement

Alspaugh (1991:53) reported that the literature on Mathematics achievement clearly document a significant positive relationship between socioeconomic status and elementary school achievement. According to Alspaugh (1991:53) socioeconomic status is measured by a wide variety of factors including parents' educational level, occupations of the parents, family income, and location of residence. Vatter (1992:292) described at-risk students as characterised by low family socioeconomic level.

On the other hand, in a study conducted on university

students in Bophuthatswana (now the North-West Province), Maqsd and Khalique (1991:382) found that Mathematics achievement did not significantly correlate with socioeconomic background.

Jones (Kohr; Masters; Coldiron; Blust & Skiffington 1989:150) found that socioeconomic status variables such as parents' occupational status and the amount of reading material in the home did relate to student performance. Carpenter reported that student achievement is influenced by the social class background of the student (Smith 1994:16).

Another study in Israel by Nimer Fayez (1990:322) also established this: The differences between boys and girls in Mathematics achievement are related to socioeconomic status. Like amongst most traditional South Africans, Nimer Fayez (1990:323) observed that the low socioeconomic status in traditional society of Arabs in Israel believe in the superiority of males over females, and encouraged superior performance by males in Mathematics - which they regard a hard and masculine subject area.

According to Oakes (Kamii 1990:396) in end-of-high-school measures of achievement, African American and Hispanic American students consistently performed below the levels of Whites and that poor students performed below their

more affluent peers. Oakland and Stern (1989:127-128) maintained that underachievement generally is thought to occur most frequently among students from poorer families whose mothers have less education.

Cherian (1993:776) in his study conducted in Transkei and Nimer Fayez (1990:323) further stated that girls from low socioeconomic status homes spend most of their time at home where most of their interaction is with other females. Those females are mostly housekeepers who have little knowledge of Mathematics. This is the case with most children in the Northern Province, RSA. This type of interaction may negatively affect the self-expectations of these girls with regard to occupations and career-related domains. It also encourages their future ideal positions as those of wife, mother, and housekeeper, as modelled by their parents. These expectations can reduce the value of Mathematics learning and make girls' good performance seem unnecessary.

Hafner (1993:72) reported a well-documented significant and positive correlation between socioeconomic status and academic achievement. Socioeconomic status is usually influenced by level of education. Wong (1992:36) found a significant positive correlation between educational levels of both parents and Mathematics achievement of their children. Luyten (1994:92) established in his study

in the Netherlands a remarkable outcome of the negative effect of the variable "parents' education" on achievement.

Cherian (1992:4) confirms the relationship between parental level of education and the scholastic achievement of their children as a widely studied and a well-documented finding. He further stated that educated parents are able to respond to school needs. Cherian (1992:6) asserted from a wide review of literature that parents' occupational level has a strong bearing on their children's scholastic achievement. This is because lower class parents may have relatively less familial support than those from higher class because the latter group earn better income to spend on their children's education than those of lower occupational status. Cherian further contended that a number of studies have shown that parents' income is positively related to the scholastic achievement of their children. This is because parents in low income families are unable to meet their children's material and physiological needs, as indicated in Maslow's hierarchy of needs (Hjelle & Ziegler 1987:368-369 & Naude & Bodibe 1990:71-72). The high income parents, however, can provide. Material poverty resulting from inadequate income can result in children's poor health and limited general knowledge which pave the way for poor achievement at school.

According to Mullis (1991:412) educated parents with higher status occupations afford buying additional reading materials like newspapers, encyclopaedia, magazines, etc., which are documented to contribute positively towards their children's academic achievement. In fact, they reported in their study, that children who indicated to have more than 25 books at home had higher achievement scores in Mathematics achievement tests.

2.2.2.3 Family Size and Pupils' Mathematics Achievement

Scott and De K Monteith (1987:78) found a strong influence of family size on academic achievement of secondary school pupils. Oakland and Stern (1989:138) reported that differences between "over- and underachievers" associated with family size also generally were not significant. Lockheed (1990:13) conducted research in Brazil and established that family size is unrelated to achievement in Mathematics. However, Cherian (1992:8) and Oakland and Stern (1989:127-128) stated that irrespective of social class, children from large families tend to perform poorly at school. Cherian further quotes literature on family size to have established a negative correlation between family size and academic achievement. Thus, research is inconclusive regarding family size influences on Mathematics achievement.

Mathematics. They further associated parents' attitudes with students' Mathematics achievement.

Pang (1991:8) in his study of Asian- and European-American middle school students cited that parental support is a significant predictor of students achievement which he contended is consistent with the findings of previous research regarding parental encouragement. Tocci and Engelhard (1991:284) also found a significant correlation between parental support and children's attitudes towards Mathematics. Campbell and Mandel (1990:72) and Kaiser-Messmer (1993:210) stated that families that provide higher levels of psychological support produced higher levels of Mathematics achievement. Randall (1990:619) asserted that differential parental encouragement produces sex differences in Mathematics. Mullis (1991:412) acknowledged that the support and encouragement students receive from their parents have an effect on students' Mathematics achievement.

Reynolds (1991:152) found a moderate positive relationship between parental aspirations and grade 8 achievement. Cherian (1992:9) referred to parental aspiration as the educational qualifications the parents wish their children to achieve. He further contended that a number of studies have shown that (1) parental aspiration is an important factor of children's academic achievement, and (2) that it

is positively related to achievement.

Tocci and Engelhard (1991:280) reported that interactions with other persons provide individuals with information in the form of attitudes, beliefs, and behaviour of significant others like parents, that become a guide for the development of their own attitudes. With parents interacting with children from birth until they reach adolescence where these attitudes start to show, they might be playing an important role in developing these attitudes.

Siskind (1994-1995:1) pointed out that, in the rural setting, negative parental attitudes towards technology compound and create almost insurmountable obstacles to introducing calculators in the classroom. This negatively impacts on pupils' Mathematics achievement.

Dickens and Cornell (1993:54-55) confirmed that role modelling is a plausible source of parental influence on adolescents' Mathematics attitudes. They further indicated that several studies suggest a high degree of paternal identification among women who are high achievers in science or Mathematics and that in a sample of extremely talented adolescents, fathers were found to be more involved with their children's mathematical activities than mothers.

2.2.2.5 Parental Mathematical Self-Concept and Pupils' Mathematics Achievement

According to Bilby, Brookover and Erickson (Wong 1992:33), "Academic self-concept refers to how one indicates to oneself his or her ability to achieve in academic tasks as compared with others engaged in the same task." Since Mathematics self-concept is a subject-specific academic self-concept (Wong 1992:33), it is justifiable to define parents' mathematical self-concept as referring to how parents indicate to themselves their ability to achieve in mathematical tasks as compared to others engaged in the same task.

Maqsud and Khalique (1991:379) reported a strong relationship between parents' Mathematics self-concept and Mathematics achievement of pupils. A negative parental Mathematics self-concept is shown by emphasising their own difficulties in learning mathematical tasks and Mathematics phobia which result in pupils' cognitive blockages and adverse impact on their achievement. Dickens and Cornell (1993:54) asserted that parents' concept of their own mathematical abilities influence their children's mathematical self-concept through a type of role modelling.

2.3 Summary

This chapter presents a review of literature on teacher and parent variables and Mathematics achievement.

Studies on teachers' attitudes, and methods reported a significant relationship between these teacher variables and Mathematics achievement. Inconclusive findings were reported for teachers' competence where a study reported poor performance of pupils despite better qualified teachers.

All factors related to the home environment (but one) were found to be significantly related to Mathematics achievement. Socio-economic status, parental attitude and parental Mathematics self-concept were documented to be significantly related to Mathematics achievement of pupils. It was only family size which had inconclusive research findings. Some researchers found family size to be significantly related to Mathematics achievement while others established no significant relationship.

CHAPTER 3: PEER GROUP AND PUPIL VARIABLES AND MATHEMATICS ACHIEVEMENT

3.1 Introduction

It is no longer sufficient for theoretical scientists alone to have a working knowledge of Mathematics. All scientists - indeed, virtually all professionals - encounter some mathematical models in much of what they do. In contrast to common belief, the availability of computers in the workplace also means that today's students need a strong mathematical background (Steen 1988:88). Emenalo and Ihejieta (1994:209) established an acclaimed notion that the study of physical sciences cannot be meaningfully tenable without a commensurate priming of students in the realm of knowledge of Mathematics.

In the previous chapter we discussed teacher and home influences on Mathematics achievement. In this chapter, we discuss peer group influences and factors in the pupils themselves, that are significantly related to Mathematics achievement.

3.2 Factors Related to Mathematics Achievement of Secondary School Pupils

3.2.1 Factors Related to the Peer Group

3.2.1.1 Introduction

Coleman (Van den Aardweg & Van den Aardweg 1988:166) referred to the peer group as "A group of youths who are attracted to one another. It is a small society, one that has most of its important interactions within itself and maintains only few threads of connections with the outside adult society."

According to Richards et al (1993:268) a peer group is a "... group of people with whom a person associates or identifies, e.g. ... members of the same class at school" The latter's definition is the one which this study will adopt in its attempt to investigate factors related to Mathematics achievement.

Maqsud and Khalique (1991:379) pointed out that significant components of learning events are: thinking, feeling and acting. These are called cognitive, affective and action domains which he contended are largely influenced by beliefs, attitudes and actions of society, family, peers and school. As indicated earlier in this

study, during adolescence, students relate well to one another but less well to the teachers and parents. The researcher therefore deems it necessary to explore the factors related to the peer group with regard to their relationship with pupils' Mathematics achievement. This is because Maheady and Sainato (1985:51) indicated that there is an increased utilisation of peer tutoring programmes to enhance the performance of low achieving children in regular and special education classrooms.

Maqsud and Khalique (1991:377) quotes Webb in his address at the annual congress of the South African Mathematics Society stating that there is a general notion that Mathematics is a subject to be avoided. Since the peer group may have this same belief, they may instil it on their friends and thus impede Mathematics achievement.

3.2.1.2 Peer Group's Attitude Towards Mathematics and Pupils' Mathematics Achievement

Dungan and Thurlow (1989:10) found from their review of literature on students' attitudes to Mathematics that students' attitudes to Mathematics have been associated with peer group attitudes. Webb (Maqsud and Khalique 1991:377) attributed poor performance of students in Mathematics to negative attitudes of the peer group towards Mathematics. Reynolds (1991:134) identified peer

attitude as one of the most influential factors in pupils' Mathematics achievement.

* Usefulness

Peer group's perceived usefulness of Mathematics refers to its view of Mathematics as necessary and applicable in everyday life, and in careers, particularly the 'prestigious' careers.

Brandon, Newton and Hammond (1987:438) in a review of the literature identified peer values and hence, also attitudes as having a strong influence on student achievement. For example, Campbell and Mandel (1990:65) found that sociopsychological forces like perceived usefulness of a subject are reinforced by the peer group. These forces have differential effects on males and females. They further indicated that as a result of these differential effects, males develop stronger Mathematics self-concepts and healthier attributions which again impact on achievement. If pupils view Mathematics as a useful subject for their future lives, they are definitely going to work hard to strengthen their mathematical background. However, if they are made to view it as irrelevant for their future lives, they will regard competence in Mathematics as unnecessary.

Cherian (1993:776) also supported the fact that perceived usefulness for later careers which is mostly derived from the important others like the peer group is the most important predictor of both boys' and girls' plans to study Mathematics and consequently of their Mathematics performance. Iben (1991:148) concluded that the attitude that Mathematics is a useful subject is an important predictor for early-adolescent success in Mathematics. Therefore, with such an influential role the peer group play during adolescence, these attitudes can be modelled by the peers. Elliot (1990):164) reported the argument of some researchers that perceived usefulness is not only related to, but perhaps a part of, one's attributions for successes and failures.

Baker and Jones (1993:92) indicated that students, particularly adolescents, receive a clear and strong message from their relevant others like the peer group that their current achievement is a kind of currency that can be spent in the future. This view is also shared by Kaiser-Messmer (1993:211). In their review of the literature, Dungan and Thurlow (1989:9) found that students' view of the importance (usefulness) of Mathematics to their society, the peer group society to be particular, has a strong effect on their subsequent achievement.

Wither (1988:50) found that students who see Mathematics as valuable may not experience high levels of test and numerical manipulation anxiety, and this further significantly correlated to achievement in Mathematics. Baker and Jones (1993:92) said that if students link attainable opportunities in the future for their current performance, they will generally intensify their effort to improve their performance.

* Gender Roles

Attitudes of the peer group towards gender roles may also influence achievement in Mathematics. Marsh (1989:193) found that sex differences in perceived value of Mathematics is frequently explained in terms of differential sex-role socialisation, and this results in girls, compared to boys, having significantly lower Mathematics self-concept and expectations. This further yields poor Mathematics performance of girls.

Hensel (1989:646) asserted that at adolescence, students become motivated by what they think their important others expect of them. He further contended that as they learn about the great scientists and mathematicians of the past, they learn that Mathematics and science are historically male-dominated fields. The very significant others

reinforce this idea by accepting poor performance in Mathematics or science from girls, yet not accepting poor performance in Mathematics and science from boys. According to Campbell and Mandel (1990:65), these sociopsychological forces influence a number of different areas in pupils like aspirations, press for independence, achievement, attributions, academic self-concepts, autonomy, interest and motivation. This idea is supported by Brandon et al (1987:438) when they say that sex role expectations by the relevant others like the peer group, and gender identity may have considerable influence on sex differences in Mathematics achievement. According to Boswell (Kaiser-Messmer 1993:210) role stereotypes, such as the assumptions that Mathematics is a male domain and that boys perform better in this area are the most important influential factors in pupils' Mathematics achievement.

Due to the fact that for social reasons high grades are not for them, girls do not generally fall under the top scoring category as often as boys do. Wilson and Boldizar (1990:63) supported this assertion by concluding that girls are often discouraged from studying Mathematics because of its masculine image.

* Supportiveness

Peer group support suggests the group's mathematical help and encouragement in co-operative (collaborative) teams (Richards et al 1993:87).

Abrami et al (1992:202 & 207) reported that students may benefit motivationally from being in groups which provide peer encouragement and support. Hence, their achievement can be improved. He further concluded that students' Mathematics achievement can improve due to the support of their group mates. Webb and Farivar (1994:370-371) also reported a significant relationship between peer group elaborated help and achievement in Mathematics which they asserted to be in keeping with previous research findings.

Nichols and Miller (1994:167) found that peer support has a positive motivational impact on learning. Hence this positively influences achievement. This finding supports what Pyle (1994:467) established as well.

3.2.2 Factors Related to the Pupil

3.2.2.1 Introduction

According to Mudeliar (1987:3), students are aware of the fact that a poor or inadequate mathematical background

could inhibit their chances of gaining suitable employment and opportunities in tertiary education, hence Mathematics being labelled a 'critical filter'. However, despite their knowledge of the key role Mathematics play, they continue to perform poorly. Many researchers have identified student characteristics that affect their Mathematics achievement. These are now discussed.

3.2.2.2 Mathematics Self-Concept and Mathematics Achievement

Mathematics self-concept will influence affective variables. These in turn, will influence Mathematics achievement. Research by, inter alia, Luyten (1994:61) and Cramer and Oshima (1992:68) has shown that students' reports of uneasiness, worry, and anxiety related to Mathematics increase during the early adolescent years. Maqsood and Khalique (1991:379) found that there was a significant positive relationship between self-concept and attitudes towards Mathematics ($r = 0.39$) for female group but no significant correlation between these variables for the male group ($r = 0.01$) was found. They went on to report that self-concept measures of both boys and girls did not reveal any significant association with their Mathematics achievement (Maqsood and Khalique 1991:386). This suggests that achievement-related affect may play a particularly important role in determining the achievement.

outcomes of young adolescents.

Nimer Fayez (1990:320) established a significant relationship between low achievement in Mathematics and high levels of Mathematics anxiety. According to Richardson and Suinn (Maqsud and Khalique 1991:387), Mathematics anxiety is referred to as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations." Maqsud et al further quoted Callahan and Glennon who stated that anxiety and Mathematics are related; high anxiety is associated with lower achievement. In support of this finding, a consistent, negative relationship between Mathematics anxiety and performance was reported by Wong (1992:33).

In keeping with the above researchers' findings, Maqsud and Khalique (1991:382), Wither (1988:50-51) and Tocci and Engelhard (1991:283) also documented a strong significant negative relationship between Mathematics anxiety and pupils' achievement in Mathematics. Meece, Wigfield and Eccles (1990:61) reported a negative effect of Mathematics anxiety on Mathematics achievement.

Hadfield and Maddux (1988:76) said that individuals suffering from Mathematics anxiety often complain of

emotional symptoms such as increased heart rate, perspiration, and loss of ability to concentrate when confronted with mathematical tasks. They went on and said such persons avoid anything that requires dealing with numbers. Maqsd and Khalique (1991:379) indicated that feelings of tension and anxiety interfere with the processes of solving mathematical problems.

In a study by Birenbaum and Gutvirtz (1993:16), three principal findings emerged: (1) The higher the test anxiety, the more likely was the examinee to commit more errors, and these errors were of the serious rather than of the non-serious type. (2) Students in the low achievement group tended to report higher levels of test anxiety and committed far more serious errors than students in the high achievement group. (3) The above findings were more pronounced for girls than for boys.

According to Covington and Omelich (Birenbaum and Gutzvirtz 1993:17) anxiety acts to inhibit test performance by temporarily blocking previously learned responses. This hypothesis was derived from the "interference" theory. The foregoing hypothesis is in accord with Hembree's (1990:33-34) assertion that Mathematics anxious people divide their attention between task-relevant efforts and preoccupations with worry, self-criticism, and somatic concerns and as a result their

performance is depressed.

Hembree (1990:34) reported that Mathematics anxiety doesn't only impinge on achievement, but also on participation in Mathematics. This reduces pupils' career options and erode the country's resource base in science and technology. Sayers (1994:401) also attributed female poor performance as compared to males to their relatively high Mathematics anxiety. Dungan and Thurlow (1989:9) also supported this finding. In line with the "interference" theory, Maqsud and Khalique (1991:379) maintained that students' anxiety may cause cognitive blockages while they solve mathematical problems.

Cramer and Oshima (1992:68) found that Mathematics anxiety did not have a significant direct effect on subsequent performance; rather the effects of Mathematics anxiety are indirect. However, Gliner (1987:86) found that Mathematics achievement was not a significant variable in predicting Mathematics anxiety scores.

Valas and Sjøvik (1993:284) concluded no reciprocal effect between school achievement and self-concept of ability, but they found that achievement significantly affected self-concept. Marsh (1988:103) on the other hand, documented that a positive self-concept in Mathematics may lead to superior performance on a subsequent Mathematics

achievement test. Bester (1988:167) found a significant relationship of $r=0.55$ between Mathematics self-concept and achievement. Wong (1992:38) also established a significant relationship between Mathematics self-concept and Mathematics achievement.

Valas and Sjøvik (1993:284) attributed girls' low achievement in Mathematics to lower self-concepts in Mathematics than boys. Meece et al (1990:60) cited that self-concept of Mathematics ability is predictive of junior and senior high school students' performance in Mathematics. Just like Rowe (1988:188), Mullis (1991:374) regarded Mathematics self-concept as a strong predictor of Mathematics performance. House (1993:66) also stated that academic self-concept is significantly related to Mathematics achievement of academically underprepared older adolescents. Accordingly, Randhawa, Beamer and Lundberg (1993:42) also reported this relationship.

In a study with 894 Hong Kong secondary school students, Wong (1992:33) found that the most important variable influencing Mathematics achievement was self-expectation - influenced by self-concept. On the basis of previous research, Luyten (1994:63) concluded that students' performance expectancies in Mathematics has the strongest positive direct effect on their subsequent grades. Concerning the predictors of Mathematics anxiety, Cramer

and Oshima (1992:68) found that students' current performance expectancies in Mathematics (in other words, their self-concepts), directly affect their anxiety. Kaiser-Messmer (1993:210) attributed boys' satisfactory performance in Mathematics to their higher expectations of success in Mathematics. Dickens and Cornell (1993:53) associated girls' poor performance with their negative expectations for their future success. Contrary to all the foregoing findings, Reynolds (1991:149) and House (1993:67) established an absence of effect for student expectations on achievement.

Enjoyment of Mathematics is strongly related to Mathematics achievement. Wither (1988:50) indicated that students expressing enjoyment of Mathematics have greater achievement potential (higher) than those who do not. In agreement with Wither's assertions, Mudeliar (1987:5) pointed out that children learn more effectively when they enjoy what they learn. Sayers (1994:397) attributed girls' poor performance in Mathematics to their lesser enjoyment of this subject area. Garofalo (1989:502) said that the emotions one feels, like enjoyment, influence the direction and outcome of one's performance.

3.2.2.3 Pupils' Attitudes and their Mathematics

Achievement

* Attitude Towards the Subject in General

Scott and De K Monteith (1987:78) inferred that students with positive attitudes usually have greater sense of responsibility, and have good intellectual proficiency and achievement potential. Norwich and Jaeger (1989:314) reported that in Mathematics, researchers tend to find a positive, but moderate, relationship between attitudes and achievement, but that attitudes contribute little to the prediction of Mathematics performance. According to Fishbein (Norwich and Jaeger 1989:323) there was evidence that pupils with more positive attitudes reported more intention to engage in future Mathematics learning behaviours. Mullis (1991:373) established that there is a direct relationship between the degree of students' positive perceptions and Mathematics proficiency. Marsh (1989:208) reported Mathematics attitudes influence Mathematics achievement. Armstrong (Kaiser-Messmer 1993:210) also considered a positive attitude towards Mathematics as the most influential factor in subsequent achievement. These studies confirmed earlier results by Cheung (1988:211).

Wong (1992:33) concluded on the basis of previous research

that when attitudes are used as predictors of achievement in Mathematics, significant positive correlations are usually found. Baker and Jones (1993:50) confirmed significant correlations between attitudes and Mathematics achievement of all students in the sample. Sayers (1994:389) stated that by age 13 boys are significantly superior to girls both in their mathematical performance and their attitudes towards Mathematics.

However, studies seem to be contradictory. Dungan and Thurlow (1989:9) asserted that little evidence exists to show that favourable attitudes necessarily lead to higher achievement. They maintained that the relationship may be reciprocal, with achievements and attitudes improving concurrently. In reviewing past studies, Gliner (1987:81) found low positive correlations between attitudes and achievement variables in Mathematics. Benbow and Stanley (Norman 1988:54) reported no significant relationship between Mathematics achievement and attitudes. Reynolds and Walberg (1992:324) established a low relationship between Mathematics attitude and Mathematics achievement.

* Attitude Towards the Teacher

Pupils' attitudes towards the Mathematics teacher also influence their Mathematics achievement.

"It's bad to count on your fingers. I was a very good student in Mathematics until about the middle of the fourth grade in elementary school. Because I continuously used my fingers to count, I was belittled and rudely treated. I was "whacked" on the knuckles many times until they hurt. Some days I didn't even want to go to school because I knew if I slipped up and used my fingers, I'd be in for another horrible day of school. My interest in Math became poorer and poorer (sic.). I can actually say I then hated Math almost as much as I came to hate that teacher."
(Martin; Moore; Strickland & Williams 1991:173)

It is evident from the quotation by Frank above that teacher behaviour can create very negative affective feelings in pupils that can hinder both their learning process and performance in Mathematics. Georgewill (1990:380) and Newman and Schwager (1993:10) found that at all grades a sense of personal relatedness with the teacher is important in determining pupils' frequency to seek help from the teacher. They further stated that this aspect of the classroom climate has been shown to be related to academic outcomes.

* Attitude Towards Gender Roles

Pupils' attitudes towards Mathematics as a male domain will also influence their performance in the subject. Randall (1990:620) confirmed that "masculine interest" girls perform significantly better at Mathematics than did

girls with "feminine values". Cramer and Oshima (1992:19) also attributed sex differences in Mathematics achievement to sex-role stereotyping. They further maintained that during adolescence, standards of achievement become more sex-stereotyped.

Hadfield and Maddux (1988:7) indicated that a girl's relative success in Mathematics is proportionate to her refusal to regard Mathematics as part of a masculine intellectual domain. Mullis (1991:379) and Marsh (1989:203) supported the above assertion when they said gender gap in achievement favouring males appears to be reinforced by some sentiment that Mathematics is more for boys than it is for girls.

Kaiser-Messmer (1993:214) also evidenced that there is a gender-based influence on the interest in Mathematics expressed by boys and girls which yields gender differences in Mathematics achievement favouring boys. This results in a negligible number of girls entering Mathematics-related careers. Cheung (1988:214) stated that boys generally viewed Mathematics as a male domain, and they viewed themselves as having more natural ability than girls which account for the sex differences in question with regard to Mathematics achievement.

Nimer Fayez (1990:322) highlighted that differences

between males and females in Mathematics achievement depend upon socioeconomic status. This is in keeping with Cherian's (1993:776) finding that girls from low socioeconomic status have no role-models at home to make them realise the importance of their high achievement in Mathematics. Cherian went on to maintain that girls may even be discouraged from studying Mathematics because of its masculine image.

Bower (1986:357) stated that youngsters consider mathematically related fields to be masculine domains, so girls are less motivated in those areas. This is why, according to Norman (1988:408), boys and girls perform equally well through the first years of high school. However, in the final years, fewer girls than boys opt for more advanced Mathematics courses. As a result of this, male students tend to score higher than females in Mathematics.

* Aspirations - Attitude Towards the Future

Van den Aardweg and Van den Aardweg (1988:24) referred to aspiration as "the desire to reach or attain that which is out of one's reach at a particular time".

Aspirations are an aspect of attitude. To the writer's knowledge, little research has been conducted to establish

the relationship between pupils' aspirations and Mathematics achievement. Cherian (1992:6) cited that pupils' aspirations are related to parental aspirations, which he reported to be correlated with pupils' academic achievement. Norman (1988:54) concluded from a wide review of literature that there is a positive correlation between career interests and Mathematics achievement. Armstrong and Price (Pedersen et al 1986:50) found that the career aspirations of high school students influenced their participation in Mathematics courses, which in turn influenced their Mathematics achievement.

3.2.2.4 Pupils' Study Methods and Mathematics Achievement

* Use of Calculator

Students' use of calculators refers to the extent of its use by pupils in class, and at home in the process of solving mathematical problems/tasks.

In a study to determine how calculator use affects Mathematics achievement in a rural high school setting, Siskind (1994-1995:3-4) established a significant positive relationship between calculator use and Mathematics word problem achievement. Munger and Loyd (1989:172) concluded that Mathematics performance is significantly related to calculator attitudes and use. This means that students

with more positive attitudes towards calculators tended to perform better in Mathematics tests. "In its position statement "Calculators in the Mathematics Classroom (1986), the NCTM recommended "the integration of the calculator into the school Mathematics programme at all grade levels in classwork, homework, and evaluation..." (NCTM stands for National Council of Teachers of Mathematics). Further, it suggested that "The evaluation of student understanding of mathematical concepts and their application, including standardised tests, should be designed to allow the use of the calculator" (Long, Reys & Osterlind 1989:318).

According to Dick (1988:38), for the most vocal opponent, the calculator is a kind of "Saturday special". This can only serve to maim students' development of basic skills. However, Dick further affirmed that bodies like the National Advisory Committee on Mathematics Education offer the advice that each student should be permitted to use the calculator during all his or her mathematical work including tests.

Mullis (1991:327-329) reported that within every state in the USA, there was a clear relationship between facility with a calculator and performance on tests, with the better skilled ones having higher scores. They further maintained that students who reported more access

to calculators had higher achievement. Long et al (1989:324) indicated that the use of calculators can allow students to demonstrate their mastery of particular Mathematics applications and operations.

* Time Spent

Time spent refers to the amount of time allocated by students to study and do tasks on Mathematics at home.

Chen et al (1988:121) found that time spent on tasks is significantly related to Mathematics achievement in the Republic of China. They also documented that the maintenance of on-task student behaviour appears to be a generic trait of classrooms having high mathematical achievement - both in China and Western cultures. Sedlacek (1990:15) suggested that doing Mathematics homework, and working Mathematics problems regularly may help improve student performance. However, Wong (1992:38) noted that the amount of time spent on Mathematics homework did not correlate with achievement or any other variable in Hong Kong where students' time spent on Mathematics homework is high.

This inconsistency in results regarding the relationship between time spent on homework and Mathematics achievement warrants further research.

3.3 Summary

The purpose of this chapter was to provide a literature review on peer group and pupil variables and how they are related to Mathematics achievement.

The literature review showed a significant relationship between all peer group attitude variables considered in this study and achievement in Mathematics.

Almost all sources reviewed for the purpose of this study reported a significant positive relationship between pupils' Mathematics self-concept, attitudes and study methods, and pupils' Mathematics achievement. The relationship to Mathematics achievement, of Mathematics self-concept and attitudes to Mathematics were reported to be more pronounced for girls.

CHAPTER 4: RESEARCH DESIGN

4.1 Introduction

In the previous two chapters, teacher, parent, peer group, and pupil variables and their relationship to Mathematics achievement were discussed. The discussions were based on the findings of a number of previous studies on similar topics.

This chapter will focus on the research design of this study of factors related to Mathematics achievement of secondary school pupils. Specific research questions, null and research hypotheses and methods to be used in carrying out this research will be listed.

4.2 Specific Research Questions

Following are specific research questions which came to the fore during the literature study that will direct the empirical research:

- (1) What is the correlation between certain variables and Mathematics achievement of secondary school pupils?

These variables are: home environment, teacher variables, peer group variables and variables related to the pupil.

- (2) What is the relative contribution of each of the variables to achievement in Mathematics?
- (3) Is there a significant difference between the Mathematics achievements of boys and girls?
- (4) Is there a significant difference between the Mathematics achievements of children from diverse socio-economic backgrounds?
- (5) Is there a significant difference between the Mathematics achievements of children taught by male teachers and those taught by female teachers?
- (6) Is there a significant difference between the Mathematics achievements of pupils taught by teachers with diverse qualifications?
- (7) Is there a significant difference between the Mathematics achievements of pupils taught by teachers with diverse experience?

- (8) Is there a significant difference between the Mathematics achievement of pupils taught by teachers with diverse levels of in-service education?
- (9) Is there a significant difference in Mathematics achievement between pupils who have frequent homework and those who have less homework?
- (10) Is there a significant difference in Mathematics achievement between students who write frequent Mathematics tests and those who write less tests?

4.3 Hypotheses

* Research Problem One

Null Hypothesis

H_0 : There is no significant correlation between certain variables and Mathematics achievement.

Research Hypothesis

H_1 : There is a significant correlation between certain variables and pupils' Mathematics achievement.

These variables are: home environment, teacher variables, peer group variables and variables related to the pupil.

* Research Problem Two

Null Hypothesis

H_0 : No variable contributes significantly towards achievement in Mathematics.

Research Hypothesis

H_1 : The following variables contribute significantly towards achievement in Mathematics: Home environment,
teacher variables,
peer group variables and
pupil variables.

* Research Problem Three

Null Hypothesis

H_0 : There is no significant difference between the Mathematics achievements of boys and girls.

Research Hypothesis

H_1 : There is a significant difference between the Mathematics achievements of boys and girls.

* Research Problem Four

Null Hypothesis

H_0 : There is no significant difference between the Mathematics achievements of children from diverse socio-economic backgrounds.

Research Hypothesis

H_1 : There is a significant difference between the Mathematics achievements of children from diverse socio-economic backgrounds.

* Research Problem Five

Null Hypothesis

H_0 : There is no significant difference between the Mathematics achievements of pupils taught by male teachers and those taught by female teachers.

Research Hypothesis

H_1 : There is a significant difference between the Mathematics achievements of pupils taught by

male teachers and those taught by female teachers.

* Research Problem Six

Null Hypothesis

H_0 : There is no significant difference in Mathematics achievements between pupils taught by well qualified teachers and those taught by teachers not well qualified.

Research Hypothesis

H_1 : There is a significant difference in Mathematics achievement between pupils taught by well qualified teachers and those taught by teachers not well qualified.

* Research Problem Seven

Null Hypothesis

H_0 : There is no significant difference in Mathematics achievements between pupils taught by experienced teachers and those taught by less experienced teachers.

Research Hypothesis

H_1 : There is a significant difference in Mathematics achievement between pupils taught by experienced teachers and those taught by less experienced teachers.

* Research Problem Eight

Null Hypothesis

H_0 : There is no significant difference in Mathematics achievements between pupils taught by teachers who have more in-service education and those taught by teachers who have less in-service education.

Research Hypothesis

H_1 : There is a significant difference in Mathematics achievements between pupils taught by teachers who have more in-service education and those taught by teachers with less in-service education.

* Research Problem Nine

Null Hypothesis

H : There is no significant difference in
Mathematics achievements between pupils who have
frequent homework and those who have less homework.

Research Hypothesis

H₁ : There is a significant difference in
Mathematics achievements between pupils who have
frequent homework and those who have less homework.

* Research Problem Ten

Null Hypothesis

H₀ : There is no significant difference in
Mathematics achievements between pupils who write
frequent Mathematics tests and those who write less
tests.

Research Hypothesis

H₁ : There is a significant difference in
Mathematics achievements between pupils who write
frequent Mathematics tests and those who write less
tests.

4.4 Research Design

The research methods in the study include a literature study and empirical research.

The literature review is presented in chapters two and three. From this review it is evident that the results of various studies of the relationship between diverse factors and Mathematics achievement of pupils are inconsistent and inconclusive. Some studies established significant and high relationships, others significant but low relationships, while others reported no significant relationships at all.

No study into the relationship between variables and pupils' Mathematics achievement has been previously documented in the specific region in the Northern Province where the researcher resides. Hence, the writer deemed it worthwhile to conduct this research in the Malamulele district, Shingwedzi-Levubu Subregion.

4.4.1 Respondents

The population included all standard 8 pupils in a certain district in the Northern Province of South Africa. A cluster sampling method was employed to select rural schools for the purpose of this study. A stratified random

sampling method on the basis of gender and location of the school (rural or urban) was used to select the sample that participated in this study.

4.4.2 Instruments

A pupil questionnaire to collect data on some variables on the teacher, the home environment, the peer group and the pupils themselves was administered to and completed by pupils.

NB: Please see Appendix A for the Questionnaire as well as the key to the Questionnaire - Appendix B. The key indicates which questions focus on which variable. The questions were formulated from the literature study in chapters two and three.

4.4.3 Procedures

Permission was obtained from the Department of Education, Sports and Culture in the Northern Province through the Area Manager. A list of schools in the district was requested for cluster sampling. The researcher made appointments with the principals and teachers, and visited schools. Lists of all standard 8 pupils at each sampled school were requested for sampling purposes. Dates were then arranged for the administration of the questionnaire.

4.4.4 Pilot Study

A pilot study with a number of standard eight pupils was conducted. A few problems with the wording of the items came to light. Therefore, the necessary changes were made to the wording of some of the items.

4.4.5 Validity

Content Validity: This refers to how well the questionnaire covers the whole field (as described in the literature study) it should cover (Mulder 1989:217). Content validity was checked by giving the questionnaire to experts in the field.

Face Validity: Face validity refers to the impression that an expert gets when reading through the questionnaire. Were the most important questions asked? In other words, face validity is a matter of judgement. The questionnaire was also given to experts to check this.

4.4.6 Reliability

Reliability refers to the extent to which we obtain information that is free of measurement error (Mulder 1989:213-214 & McMillan & Schumacher 1993:227). If an

instrument is reliable, the information is stable. Also, similar results are obtained when the instrument is used more than once to measure the same thing.

Reliability measurements are presented as correlation coefficients. The higher the correlation value, the more reliable the instrument. It ranges from -1.0 to +1.0. The computer programme which was used to analyse the results, is the Statistical Analysis Systems. This programme makes use of the Cronbach alpha-coefficient. This is a split-halves method. The result is the same as that which is obtained by using Kuder-Richardson-Formula 20 (Mulder 1993:213-214).

4.5 Analysis of Data

4.5.1 Statistical Techniques

Statistical analysis was done by the Department of Computer Science of the University of South Africa. The Pearson's Product Moment Correlation Coefficient was calculated to test hypotheses on correlation as listed under 4.3.

Stepwise regression analysis was used to test the hypothesis on the relative contribution of each variable to achievement in Mathematics.

A t-test was used to test hypotheses on the significance of the difference between two means on the different variables.

To test for significant differences between diverse achievements, Analyses of Variance (F-test) were calculated. The hypotheses were tested at both the 0.05 and 0.01 levels of significance.

4.6 Summary

This chapter discussed how the ten research problems in this study are investigated, using an empirical research design. The various statistical techniques that are used in the testing of the hypotheses in this study were also identified.

In the next chapter, the results of the empirical investigation will be presented and discussed.

CHAPTER 5: RESULTS AND DISCUSSION

5.1 Introduction

In this chapter, results of statistical analyses of data with regard to: home environment, teacher variables, peer group variables and pupil variables are presented and discussed.

5.2 Results

5.2.1 Frequencies

The frequencies are as follows:

* For achievement in Mathematics

0 - 19%	21
20 - 39%	33
40 - 59%	66
60 - 79%	21
80% +	21

Frequency missing: 1

* For gender

Male	99
Female	61

Frequency missing: 3

* For age:

< =17 years	80
18 years	36
19 years	13
20 years	7
21 years	12
22 years	3
23 years	1
24 years	7

Frequency missing: 4

* For father's income:

none	23
R1 - 999	21
R1 000 - 2 999	14
R3 000 - 6 999	6

R7 000 +	1
don't know	94

Frequency missing: 4

* For mother's income:

none	56
R1 - 999	19
R1 000 - 2 999	11
R3 000 - 6 999	4
R7 000+	6
don't know	63

Frequency missing: 4

* For frequency of Mathematics tests:

never	4
quarterly	28
monthly	113
fortnightly	13
weekly	5

* For frequency of Mathematics homework:

never	1
weekly	17
twice per week	23
thrice per week	18
four times per week	20
daily	83

Frequency missing: 1

* For teacher qualification:

std 10 + Mathematics	5
std 10 + degree	1
std 10 + diploma	84
degree + diploma	61
postgraduate + diploma	2
don't know	7

Frequency missing: 3

* For teacher experience:

none	15
1 - 4 years	34

5 - 8 years	45
9 - 12 years	36
13 - 16 years	23
17 + years	3
don't know	5

* For teacher's involvement in in-service education:

never	2
1 - 4 years	129
5 - 8 years	22
9 times +	1
don't know	9

* For teacher's gender:

male	112
female	50

Frequency missing: 1

5.2.2 Problem Statement 1

What is the correlation between certain variables and Mathematics achievement of secondary school pupils?

Null Hypothesis 1: There is no significant correlation between certain variables and Mathematics achievement of secondary school pupils.

Experimental Hypothesis 1: There is a significant correlation between certain variables and Mathematics achievement of secondary school pupils.

These variables are:

Home environment,
teacher variables,
peer group variables, and
pupil variables

The results are shown in Table 4.

**TABLE 4 CORRELATION OF VARIABLES WITH ACHIEVEMENT IN
MATHEMATICS**

Variable	Correlation with achievement in Mathematics	Probability
Home environment	0.05	$p > 0.05$
Teacher variables	0.02	$p > 0.05$
Peer group variables	0.15	$p > 0.05$
Pupil variables	0.24	$p < 0.01$

According to Table 4, all the correlations between the diverse variables and achievement in Mathematics are low. However, this may be influenced by small sample size. The highest positive correlation with Mathematics was pupil variables. This correlation is significant on the 1% level of significance.

Pupils variables include the following:

pupils' self-concepts,
pupils' attitudes and

pupils' study methods.

5.2.3 Problem Statement 2

What is the relative contribution of each of the variables to achievement in Mathematics?

Null Hypothesis 2: There is no variable that contributes significantly towards Mathematics achievement of secondary school pupils.

Experimental Hypothesis 2: There are certain variables that contribute significantly towards Mathematics achievement of secondary school pupils.

Stepwise regression analysis reveals the following:

**TABLE 5 STEPWISE REGRESSION ANALYSIS FOR CORRELATION
WITH ACHIEVEMENT IN MATHEMATICS**

Step	Factor	Partial variance	F-value	Probability
1	Pupil variables	0.57	23.8054	$p < 0.01$

Table 5 indicates that one variable contributes significantly towards the variance in achievement in Mathematics, namely pupil variables: 57% of the variance in Mathematics achievement is caused by this variable.

Further analysis indicated that of the pupil variables, pupils' self-concepts contributed most towards achievement in Mathematics.

5.2.4 Problem Statement 3

Is there a significant difference between the Mathematics achievements of boys and girls?

Null Hypothesis 3: There is no significant difference between the Mathematics achievements of boys and girls.

Experimental Hypothesis 3: There is a significant difference between the Mathematics achievements of boys and girls.

To test this hypothesis, a t-test was done. The results appear in Table 6.

TABLE 6 T-VALUES FOR MATHEMATICS ACHIEVEMENTS OF BOYS AND GIRLS

Gender	N	Mean	df	t-value	Probability
Male	98	2.9286	157	0.32	$p > 0.05$
Female	61	2.8689			

According to Table 6, the male pupils achieved better at Mathematics than the female pupils. This difference, however, is not significant since the probability is greater than 0.05. (If the sample was greater, this difference may have been significant.)

5.2.5 Problem Statement 4

Is there a significant difference between the Mathematics achievements of children from diverse socio-economic backgrounds?

Null Hypothesis 4: There is no significant difference between the Mathematics achievements of children from diverse socio-economic backgrounds.

Experimental Hypothesis 4: There is a significant difference between the Mathematics achievements of children from diverse socio-economic backgrounds.

To test this hypothesis analysis of variance (an F-test) was conducted. The results are as follows:

TABLE 7 F-VALUE AND PROBABILITY OF DIFFERENCE BETWEEN MATHEMATICS ACHIEVEMENTS OF CHILDREN FROM DIVERSE SOCIO-ECONOMIC BACKGROUND

Df	F-value	Probability
4	1.2716	$p > 0.05$

According to Table 7, the groups did not differ significantly with regard to Mathematics achievement on the 5%-level of significance.

5.2.6 Problem Statement 5

Is there a significant difference between the Mathematics achievements of children taught by male and female teachers?

Null Hypothesis 5: There is no significant difference between the Mathematics achievements of children taught by male and female teachers.

Experimental Hypothesis 5: There is a significant difference between the Mathematics achievements of children taught by male and female teachers.

A t-test was done to test the null hypothesis. Table 8 illustrates the results.

TABLE 8 T-VALUES FOR MATHEMATICS ACHIEVEMENTS OF
PUPILS WITH MALE AND FEMALE TEACHERS

Gender of teacher	N	Mean	df	t-value	Probability
Male	112	2.8393			
Female	49	3.1224	159	1.41	$p > 0.05$

According to Table 8, pupils with female teachers achieved better at Mathematics than pupils with male teachers. This difference, however, was not significant since the probability is greater than 0.05.

5.2.7 Problem Statement 6

Is there a significant difference between the Mathematics achievements of pupils taught by teachers with diverse qualifications?

Null Hypothesis 6: There is no significant difference between the Mathematics achievements of children taught by teachers with diverse qualifications.

Experimental Hypothesis 6: There is a significant difference between the Mathematics achievements of children taught by teachers with diverse qualifications.

Teacher qualifications were grouped into the following 5 categories:

std. 10;

std. 10 plus degree;

std. 10 plus diploma;

std. 10, degree in Mathematics plus diploma in Mathematics;

postgraduate qualifications in Mathematics.

With analysis of variance to test the null-hypothesis, the following results were obtained:

TABLE 9 F-VALUE AND PROBABILITY OF DIFFERENCE BETWEEN
MATHEMATICS ACHIEVEMENTS OF CHILDREN TAUGHT
BY TEACHERS WITH DIVERSE QUALIFICATIONS

Df	F-value	Probability
4	1.2856	$p > 0.05$

According to Table 9, the groups did not differ significantly with regard to Mathematics achievement on the 5%-level of significance.

5.2.8 Problem Statement 7

Is there a significant difference between the Mathematics achievements of pupils taught by teachers with diverse experience?

Null Hypothesis 7: There is no significant difference between the Mathematics achievements of children taught by teachers with diverse experience.

Experimental Hypothesis 7: There is a significant difference between the Mathematics achievements of children taught by teachers with diverse experience.

Teachers' experience were grouped into 5 categories, namely:

up to 4 years;
5 - 8 years;
9 to 12 years;
13 to 16 years;
17 years and more.

To test the null hypothesis, analysis of variance was done. This revealed the following:

TABLE 10 F-VALUE AND PROBABILITY OF DIFFERENCE
BETWEEN MATHEMATICS ACHIEVEMENTS OF CHILDREN
TAUGHT BY TEACHERS WITH DIVERSE LEVELS OF
EXPERIENCE

Df	F-value	Probability
4	1.5121	$p > 0.05$

According to Table 10, the groups did not differ significantly with regard to Mathematics achievement on the 5%-level of significance.

5.2.9 Problem Statement 8

Is there a significant difference between the Mathematics achievements of pupils taught by teachers with diverse levels of in-service education?

Null Hypothesis 8: There is no significant difference between the Mathematics achievements of children taught by teachers with diverse levels of in-service education.

Experimental Hypothesis 8: There is a significant difference between the Mathematics achievements of children taught by teachers with diverse levels of in-service education.

Once more, analysis of variance was done to determine to what extent in-service education could influence achievement in Mathematics. The results appear in Table 11.

TABLE 11 F-VALUE AND PROBABILITY OF DIFFERENCE
BETWEEN MATHEMATICS ACHIEVEMENTS OF CHILDREN
TAUGHT BY TEACHERS WITH DIVERSE LEVELS OF
IN-SERVICE EDUCATION

Df	F-value	Probability
4	0.6788	$p > 0.05$

According to Table 11, the groups did not differ significantly with regard to Mathematics achievement on the 5%-level of significance. Once more it should be taken

into consideration that the sample was relatively small.

5.2.10 Problem Statement 9

Is there a significant difference between the Mathematics achievements of pupils who have frequent homework and those who have less homework?

Null Hypothesis 9: There is no significant difference between the Mathematics achievements of pupils who have frequent homework and those who have less homework.

Experimental Hypothesis 9: There is a significant difference between the Mathematics achievements of pupils who have frequent homework and those who have less homework.

To test this hypothesis, a t-test was done after arranging the pupils into two groups. The results appear in Table 12.

TABLE 12 T-VALUES FOR MATHEMATICS ACHIEVEMENTS OF
PUPILS WITH FREQUENT AND WITH LESS HOMEWORK

Frequency of homework	N	Mean	df	t-value	Probability
Less homework	41	2.6341			
More homework	120	3.0250	159	1.85	$p > 0.05$

According to Table 12, pupils who had more homework to do (daily, four times per week, or thrice per week) achieved better than pupils who had less homework to do (never, once per week or twice per week). However, this difference was not statistically significant.

5.2.11 Problem Statement 10

Is there a significant difference between the Mathematics achievements of pupils who wrote frequent tests and those who wrote less frequent tests?

Null Hypothesis 10: There is no significant difference between the Mathematics achievements of pupils who wrote frequent tests and those who wrote less frequent tests.

Experimental Hypothesis 10: There is a significant difference between the Mathematics achievements of pupils who wrote frequent tests and those who wrote less frequent tests.

A t-test was done to test the null-hypothesis. The results appear in Table 13.

TABLE 13 T-VALUES FOR MATHEMATICS ACHIEVEMENTS OF PUPILS WHO WROTE FREQUENT AND LESS FREQUENT TESTS

Frequency of tests	N	Mean	df	t-value	Probability
Less tests	32	3.0000			
More tests	130	2.9077	160	0.40	$p < 0.05$

According to Table 13, pupils who wrote less tests (not more than once per term) achieved significantly better on

the 5%-level of significance than pupils who wrote tests more often (weekly, every two weeks or once per month).

5.3 Discussion

5.3.1 Introduction

This study focused upon ten questions. The research questions involved the relationship between (a) the home environment and Mathematics achievement; (b) some teacher variables and Mathematics achievement; (c) some peer group variables and Mathematics achievement; and (d) some pupil variables and Mathematics achievement of secondary school pupils.

5.3.2 Discussion of Results

This study established low positive correlations between the different variables and achievement in Mathematics. Correlation with achievement in Mathematics of: Home environment is 0.05 ($p > 0.05$); teacher variables is 0.02 ($p > 0.05$) and peer group variables is 0.15 ($p > 0.05$). The highest correlation with Mathematics achievement, was pupil variables with $r = 0.24$. This correlation was significant on the 1% - level of significance. Though low, the correlation of home environment with Mathematics

achievement is consistent with previous research findings (Kaiser-Messmer (1991:71-72); Campbell and Mandel (1991:71 - 72) and Marjoribanks (1987:121)). Hafner (1992:212) reported a general relationship between teacher variables and student achievement. (See section 2.2.2). However, these low correlations cannot be generalised.

Of importance are the implications of pupil variables for teachers and for further research regarding Mathematics achievement. The pupil variables which were considered for this study include pupils' self-concepts, pupils' attitudes and pupils' study methods. This finding is in keeping with Bester's (1988:167) and Wong's (1992:38) findings that Mathematics self-concept is significantly related to pupils' Mathematics achievement. Nimer Fayez (1990:320) found a significant relationship between low achievement in Mathematics and high level of Mathematics anxiety. (See section 3.2.2).

Amongst the three variables other than pupil variables, the peer group variables have the highest correlation with achievement in Mathematics. The emergence of pupil and peer group variables having the highest correlation with achievement in Mathematics may be attributed to the new social orientation in the adolescent stage. At this stage of development, students may relate well to one another but less well to teachers and parents (Boling 1991:17-18).

The second question investigated the relative contribution of each of the variables to achievement in Mathematics. Of the four variables in this study, one variable contributes significantly towards the variance in achievement in Mathematics, namely pupil variables. It came to light in this study that 57% of the variance in Mathematics achievement is caused by this variable. It was also established that of the pupil variables, pupils' self-concepts contributed most towards achievement in Mathematics. This further indicates the role self-fulfilling prophecy may play in shaping one's achievements: One often becomes what one thinks one is.

The third question aimed to establish if there is a significant difference between the Mathematics achievements of boys and girls. The results of the t-test suggest that in accordance with findings of previous studies, male pupils achieved better at Mathematics than the female pupils. This difference, however, is not significant since $p > 0.05$ (If the sample was greater, this difference may have been significant).

The fourth research question investigated if there is a significant difference between the Mathematics achievements of children from diverse socio-economic backgrounds. The results of the analysis of variance

(F-test) demonstrate that the groups did not differ significantly with regard to Mathematics achievement on the 5% - level of significance. This supports the theory of change in socialisation patterns among adolescents (Boling 1991:18). This theory reports a decline in the influence of parents on their adolescent children, which may result in a decline in socioeconomic home background influence on pupils' Mathematics achievements as well.

In answering the fifth question, it was found that pupils with female teachers achieved better at Mathematics than pupils with male teachers. This may be due to female teachers' friendly attitudes towards pupils. (See section 2.2.1). According to Newman & Schwager (1993:10), a sense of personal relatedness with the teacher is important in determining who seeks help from the teacher and who does not. If pupils know that the response is negative when they ask questions, they may simply keep quiet to protect their sense of self-worth. Female teachers' often soft-heartedness may be an inviting factor to pupils' help-seeking and hence enhance performance. The difference in Mathematics achievements by pupils with male or with female teachers in this study, however, was not significant since the probability is greater than 0.05. However, it should be remembered that the sample was relatively small.

Question six focused on the difference in Mathematics achievement by pupils taught by teachers with diverse qualifications. The result is in line with Maqsd and Khalique (1991:379) who established in their study that in spite of the availability of well qualified Mathematics teachers in some Bophuthatswana (now North-West Province) schools, the std 10 results were poor. Accordingly, this study also established no significant difference in Mathematics achievements by pupils taught by better qualified teachers and those taught by less qualified teachers. This may be because of poor teacher education. Informal interviews indicate that college graduate programmes often stress methodology and give less room for teacher pre-service development regarding advanced content. Often colleges would repeat what student teachers did in high school as academic content, whereas advanced content breeds confidence in teachers.

The seventh research question examined if there is a significant difference between the Mathematics achievements of pupils taught by teachers with diverse experience. The analysis of variance revealed that the groups did not differ significantly with regard to Mathematics achievement (on the 5% - level of significance). This finding contradicts Lockheed and Komenan's (1989:95) and Mullis' (1990:224) research finding that teaching experience is related to student

achievement in developing countries. (See section 2.2.1). However, it should again be taken into account that the sample was relatively small.

The ninth research question focused upon establishing whether there is a significant difference between the Mathematics achievements of pupils who have frequent homework and those who have less homework or no homework at all. A t-test was done after dividing the pupils into two groups as shown in Table 12. The t-value = 1.85 ($p > 0.05$) suggests that pupils who had more homework to do (daily, four times per week, or thrice per week) achieved better than pupils who had less homework to do (never, once per week or twice per week). This result is in accord with most previous research findings (Mullis 1990:351; Sedlacek 1990:15). (See section 2.2.1.4). However, this difference was not statistically significant. Nonetheless, homework may enhance learning and achievement through practice and application (Cobb; Peach & Craig 1990:168).

The last question aimed at investigating the difference between the Mathematics achievements of pupils who wrote frequent tests and those who wrote less frequent tests. A t-test found that pupils who wrote less tests (not more than once per term) achieved significantly better on the 5% - level of significance than pupils who wrote tests more often (weekly, every two weeks or once per month).

This finding is inconsistent with Dineen et al (1989:200) who reported that there were no significant differences between test scores of students who were tested weekly and those who wrote tests only at the end of every semester. (See section 2.2.1.4). If pupils achieve less when writing more tests, this may be because pupils who write tests more frequently are anxious due to their preoccupation with fears of tests and this impede their learning. Again, poor performance due to a congested test schedules may discourage pupils and negatively affect their attitudes towards the subject.

On the other hand, pupils who write tests less frequently may achieve well because they get time to study their work free of the pressures of preparing for a series of tests. This enables them to identify aspects of the work they do not understand and seek help from teachers. Their Mathematics anxiety may be lessened by a learning atmosphere which is free of continuous test anxiety. These factors may enhance their achievement in Mathematics.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The purpose of this study was to investigate if factors related to the home environment, to the teacher, to the peer group and to the pupils themselves are significantly related to achievement in secondary school Mathematics. Despite intensive studies in other countries, there have been hardly any empirical study conducted in the South African context in general, and in Shingwedzi-Levubu Subregion (Northern Province) in particular, on factors related to Mathematics achievement of secondary school pupils. Therefore, the findings of this study will add to the knowledge already established on factors related to Mathematics achievement in the context of the area mentioned above.

Ten research problems were formulated to guide the researcher in conducting this study. Following are the problem statements and their respective null hypotheses:

Problem Statement 1: What is the correlation between certain variables and Mathematics achievement of secondary school pupils?

Null Hypothesis 1: There is no significant correlation between certain variables and Mathematics achievement.

These variables are: Home environment, teacher variables, peer group variables and variables related to the pupil.

Problem Statement 2: What is the relative contribution of each of the variables to achievement in Mathematics?

Null Hypothesis 2: No variable contributes significantly towards achievement in Mathematics.

Problem Statement 3: Is there a significant difference between the Mathematics achievements of boys and girls?

Null Hypothesis 3: There is no significant difference between the Mathematics achievements of boys and girls.

Problem Statement 4: Is there a significant difference between the Mathematics achievements of children from diverse socio-economic backgrounds?

Null Hypothesis 4: There is no significant difference between the Mathematics achievements of children from

diverse socio-economic backgrounds.

Problem Statement 5: Is there a significant difference between the Mathematics achievements of children taught by male teachers and those taught by female teachers?

Null Hypothesis 5: There is no significant difference between the Mathematics achievements of pupils taught by male teachers and those taught by female teachers.

Problem Statement 6: Is there a significant difference between the Mathematics achievements of pupils taught by teachers with diverse qualifications?

Null Hypothesis 6: There is no significant difference in Mathematics achievements between pupils taught by teachers with diverse qualifications.

Problem Statement 7: Is there a significant difference between the Mathematics achievements of pupils taught by teachers with diverse experience?

Null Hypothesis 7: There is no significant difference in Mathematics achievements between pupils taught by teachers

with diverse experience.

Problem Statement 8: Is there a significant difference between the Mathematics achievements of pupils taught by teachers with diverse levels of in-service education?

Null Hypothesis 8: There is no significant difference in Mathematics achievements between pupils taught by teachers with diverse levels of in-service education.

Problem Statement 9: Is there a significant difference in Mathematics achievement between pupils who have frequent homework and those who have less homework?

Null Hypothesis 9: There is no significant difference in Mathematics achievements between pupils who have frequent homework and those who have less homework.

Problem Statement 10: Is there a significant difference in Mathematics achievement between students who write frequent Mathematics tests and those who write less tests?

Null Hypothesis 10: There is no significant difference in Mathematics achievements between pupils who write frequent

Mathematics tests and those who write less tests.

6.2 Conclusions

6.2.1 Conclusions from the Literature Study

Problem Statement 1

* Teacher Variables

Literature review predominantly shows teacher variables to be significantly related to pupils' Mathematics achievement. Teachers' attitudes towards Mathematics was documented a variable significantly related to Mathematics achievement of pupils (Tooke 1993:274 & Mudeliar 1987:4) (See section 2.2.1.2). Dungan and Thurlow (1989:10) also reviewed literature on student attitudes towards Mathematics and concluded that pupils derive their attitudes from those of their teachers. Therefore, if teachers hold negative attitudes towards Mathematics so do their pupils. This in turn adversely affects pupils' achievement in Mathematics.

Teachers' attitudes towards the pupils themselves also influence pupils' attitudes towards Mathematics. Teachers' expectations of the pupils are reported to be highly and

significantly correlated to pupils' achievement in Mathematics. If the pupil believes that a teacher has a low opinion of him/her, the likelihood is that the pupil may perform as expected (Cheung 1988:316 & Sayers 1994:397-399).

Teachers' attitudes towards gender roles also emerged a variable significantly related to pupil achievement in Mathematics. This was cited as accounting for gender stereotypic behaviour and sex-related differences in Mathematics learning and achievement (Hensel 1989:650 & Randal 1990:619).

Teachers' competence i.e. the amount of education a teacher received, confidence, experience, and in-service education were all found to be significantly related to pupils' Mathematics achievement (Georgewill 1990:383; Bracey 1991:86; Tooke 1993:274-276; Chen et al 1988:116 & Lockheed and Komenan 1989:105). Inconclusive and contradictory research findings were observed with regard to teachers' education and experience (Maqsud and Khalique 1991:379 & Mullis 1991:385).

The literature study also revealed a significant relationship between teachers' methods and Mathematics achievements of pupils. Some researchers reported a significant, positive relationship between the use of

small groups in teaching Mathematics and students' Mathematics achievement (Abrami et al 1992:207). In contrast, Schaub and Baker (1991:635) indicated that having students work in small groups lower their performance. These contradictory findings show that research is still inconclusive with regard to the use of co-operative learning strategies. Use of teaching aids (instructional aids) was also documented to be significantly, positively related to student achievement (Mullis 1991:300).

Research on the effect of homework on Mathematics achievement also posed inconclusive results. Some studies found that students who do more homework had low achievement scores (Mullis 1991:351). On the other hand, Sedlacek (1990:15) and Mudeliar (1987:38) reported a positive relationship between daily Mathematics homework and pupils' Mathematics achievement.

Content coverage was reported to be significantly related to Mathematics achievement (Chen et al 1988:116; Raphael 1989:173; Hafner 1993:83 & Lockheed 1990:18). Research on testing frequency established that achievement improves as the rate of testing increases (Kika et al 1992:159; Ma 1995:17 & Dineen et al 1989:200).

Teachers' personality was also documented as being

significantly related to pupils' Mathematics achievement. Mudeliar (1987:40) and Dungan and Thurlow (1989:9) both concluded that whether a teacher is liked or disliked by pupils influences the child's attitude towards that subject, and subsequently their achievement.

* The Home Environment

Many studies reported that family environment influences are significantly related to Mathematics achievement of pupils (Kaiser-Messmer 1993:210; Campbell and Mandel 1990:71-72 & Marjoribanks 1987:121). (See section 2.2.2).

Literature on socio-economic status and Mathematics achievement documents this variable to be significantly and positively related to Mathematics achievement of pupils (Alspaugh 1991:53; Maqsud and Khalique 1991:382; Kohr et al 1989:150; Smith 1994:16; Kamii 1990:396; Oakland and Stern 1989:127-128; Hafner 1993:72; Luyten 1994:92; Cherian 1992:4-6 & Mullis 1991:412). (See section 2.2.2.2).

Family size and pupils' Mathematics achievement were also reported to be significantly correlated (Scott and De Monteith 1987:78; Cherian 1992:8 & Oakland and Stern 1989:127-128). However, the findings are inconclusive since Lockheed (1990:13) found no relationship between

family size and Brazilian pupils' Mathematics achievement.
(See section 2.2.2.3).

Parental attitudes were established as significantly related to Mathematics achievement of pupils (Klebanov and Brooks-Gunn 1992:81). Parental expectations for their children's achievement in Mathematics were not only found to be significantly related to pupils' achievement in Mathematics, but also to pupils' self-expectations, self-concepts and attitudes regarding Mathematics achievement (Reynolds 1991:133; Dickens and Cornell 1993:54; Wong 1992:38 & Klebanov and Brooks-Gunn 1992:94).
(See section 2.2.2.4).

All research literature reviewed on parental support and encouragement established a significant relationship between these variables on parental attitudes and pupils' Mathematics achievements (Pang 1991:8; Tocci and Engelhard 1991:248 & Mullis 1991:412). Parental aspirations were also found to be moderately and positively related to grade 8 achievement (Reynolds 1991:152). Maqsud and Khalique (1991:379) and Dickens and Cornell (1993:54) found a significant relationship between parents' Mathematics self-concept and Mathematics achievement of pupils. (See section 2.2.2.5).

* Peer Group Variables

The peer group's attitudes towards Mathematics were found to be significantly related to students' attitudes to Mathematics and their Mathematics achievement (Dungan and Thurlow 1989:10; Maqsd and Khalique 1991:377 & Reynolds 1991:134) (See section 3.2.1.2). The peer group's perceived usefulness of Mathematics was reported to be attributed to gender-stereotypes which results in males developing stronger Mathematics self-concepts and hence a better performance in Mathematics than girls (Brandon et al 1987:438; Campbell and Mandel 1990:65 & Kaiser-Messmer 1993:210).

Abrami et al (1992:202 & 207), Nichols and Miller (1994:167), Pyle (1994:467) and Webb and Farivar (1994:370-371) reported a significant, positive relationship between peer group encouragement and pupils' Mathematics achievements.

* Pupil Variables

Research reports reviewed documented a significant, positive relationship between pupils' self-concepts and their Mathematics achievement (Valas and Sovik 1993:284; Marsh 1988:103; Bester 1988:167; Wong 1992:38; House 1993:66; Mullis 1991:374 & Randhawa et al 1993:42). (See

section 3.2.2). Valas and Sjøvik (1993:284) indicated that girls' lower self-concepts in Mathematics in comparison with boys were associated with their lower achievements in Mathematics. Wong (1992:33) also reported that self-expectation is the most influential factor in Mathematics achievement.

Previous research on Mathematics anxiety found a significant, negative relationship between this variable and achievement in Mathematics (Nimer Fayez 1990:320; Wong 1992:33; Maqsd and Khalique 1991:382; Wither 1988:50-51; Tocci and Engelhard 1991:283; Meece et al 1990:61; Birenbaum and Gutvirtz 1993:16; Hembree 1990:33-34 & Gliner 1987:86). (See section 3.2.2.2)

Research also established that boys' satisfactory performance in Mathematics is related to their high expectations of success in Mathematics (Cramer and Oshima 1992:68 & Kaiser-Messmer 1993:210). Dickens and Cornell (1993:53) attributed girls' poor performance to their negative expectations for their future performance in Mathematics. However, findings contrary to the afore-mentioned ones were brought to the fore by Reynolds (1991:149) and House (1993:67) who established an absence in the effect of students' expectations on achievement in Mathematics. Research findings on pupils' expectations are therefore inconclusive.

Enjoyment of Mathematics was also a variable which was found to be significantly related to Mathematics achievement (Wither 1988:50; Mudeliar 1987:5; Sayers 1994:397 & Garofalo 1989:502).

Previous studies on pupils' attitudes reported a positive relationship between pupils' attitudes and pupils' Mathematics achievement (Norwich & Jaeger 1989:314; Mullis 1991:373; Marsh 1989:208; Kaiser-Messmer 1993:210; Cheung 1988:211 & Baker and Jones 1993:50). However, Norman (1988:54) reported no significant relationship between Mathematics achievement and attitudes. Thus, research findings on the relationship between pupils' attitudes towards Mathematics and Mathematics achievement are inconclusive. (See section 3.2.2.3.)

Pupils' attitudes towards the teacher was found to influence pupils' Mathematics achievement (Georgewill 1990:380 & Newman & Schwager 1993:10).

Pupils' future aspirations were significantly related to their Mathematics achievements. Career aspirations in particular were found to correlate positively with pupils' achievements in this subject (Norman 1988:54 & Pedersen et al 1986:50).

Research found some pupils' study methods to be significantly related to their Mathematics achievement. However, research findings on some methods were inconclusive. Calculator use was found to be positively and significantly related to pupils' Mathematics achievement (Siskind 1994-1995:3-4; Munger and Loyd 1989:172 & Mullis 1991:327-329). Chen et al (1988:121) and Sedlacek (1990:15) found time spent on homework to be significantly related to Mathematics achievement. On the other hand, Wong (1992:38) established that time spent on homework did not significantly correlate with achievement in Mathematics. These contradictory findings make research on this variable inconclusive. (See section 3.2.2.4.)

Problem Statement 2

Research identified peer group variables as contributing significantly to adolescent Mathematics achievement (Boling 1991:17-18 & Brandon et al 1987:438). Boling attributed this to the theory of change in socialisation patterns during adolescence. Adolescents relate well to the peer group and less well to teachers and parents. This explains the rise in peer group influence during this developmental stage. A finding contrary to the afore-mentioned emerged from Reynold's (1991:148) research. He found that peers had negligible influence on grade 8 Mathematics achievement.

However, the literature study reveals that most pupil variables are shaped by peer group variables. Dungan and Thurlow (1989:10) reviewed the literature and found peer group influences to be associated with students attitudes. Webb (Maqsud and Khalique 1991:377) attributed poor performance of students in Mathematics to negative attitudes of the peer group towards Mathematics. Campbell and Mandel (1990:65) found that socio-psychological forces like perceived usefulness of a subject are reinforced by the peer group. Sex-role stereotypes like viewing Mathematics as a male domain are drawn from the peer group (Marsh 1989:193). Peer group support and encouragement were also found to have a positive motivational impact on achievement (Nichols and Miller 1994:167 & Abrami et al 1992:202 & 207). Thus, despite the slight inconsistency, we can conclude that peer group variables contribute significantly to Mathematics achievement.

Problem Statement 3

Review of previous research leads to a conclusion that there is a significant difference between the Mathematics achievement of boys and girls at this stage of development, namely adolescence (Hensel 1989:646; Cramer Oshima 1992:19 & Bosker and Dekkers 1994:179). For instance, Xu & Farrel (1992:442) ; Marsh (1989:192) and

Ethington (1990:74) stated it categorically that there is a significant difference in school mathematical performance in favour of males during adolescence.

Problem Statement 4

Previous studies suggested a difference between the Mathematics achievements of pupils from diverse socio-economic backgrounds (Cherian 1993:775; Kamii 1990:396; Cherian 1992:7; Kohr, Masters, Coldiron, Blust & Skiffington 1989:150 & Oakland & Stern 1989:137). (See section 2.2.2.2.)

Problem Statement 5

Sayers (1994:400-401) found that teacher's gender significantly influenced attitudes towards Mathematics and hence achievement as well. A male teacher is associated with more stereotyped attitudes among pupils, while a female teacher is associated with a concurrence of attitudes among boys and girls (Sayers 1994:400-401). These differences in attitudes imply differences in pupils' Mathematics achievement as well.

The literature review, therefore, suggests a significant difference between the Mathematics achievements of boys or girls when they are taught by male and female teachers.

Problem Statement 6

Most research findings suggest a significant difference between the Mathematics achievements of pupils taught by well qualified teachers and those taught by teachers not well qualified (Lockheed and Komenan 1989:94; Mullis 1991:386; Bracey 1991:86 & Tooke 1993:274-276). However, Maqsd and Khalique (1991:379) noted a poor performance in matriculation in some Bophuthatswana (now part of the North-West Province) schools, despite the availability of well qualified Mathematics teachers.

Problem Statement 7

Emerging from some studies is the finding that there is a significant difference in Mathematics achievements by pupils taught by more experienced teachers and those taught by less experienced teachers. The difference is mostly in favour of pupils taught by more experienced teachers (Lockheed and Komenan 1989:105; Mullis 1991:384 & Chen et al 1988:116).

Problem Statement 8

Research by Mullis (1991:389) brought to light the conclusion that in the majority of states in the USA,

eighth graders whose teachers had more in-service education performed better than those whose teachers reported less in-service education.

Problem Statement 9

Inconclusive findings were established in a number of studies conducted about the relationship between the amount of homework and achievement in Mathematics. Cobb et al (1990:170) could not find a significant difference in achievement when homework was done or not done. On the other hand, Mullis (1991:351) found that in some states in the USA, students who reported doing more homework had low achievement scores.

Problem Statement 10

Some previous researches established no significant differences between Mathematics achievements of students who were more frequently tested and those who were less frequently tested (Dineen et al 1989:200). In contrast, other studies reported a significant difference between pupils who wrote more frequent tests and those who wrote less frequent tests. Thus, research on the probable influence of frequency of testing is inconclusive.

6.2.2 Conclusions from the Empirical Research

Problem Statement 1

Though low, this study established positive correlations between the diverse variables and achievement in Mathematics. This finding is consistent with previous research findings. Of special interest in this study is that pupil variables were found to correlate highest with Mathematics achievement of secondary school pupils. The correlation is positive and significant on the 1%-level. Thus the null-hypothesis is rejected with regard to pupil variables.

Problem Statement 2

The empirical research in this study indicates that one variable contributes significantly towards the variance in achievement in Mathematics, namely pupil variables. 57% of the variance in Mathematics achievement is found to be caused by this variable. When the pupil variables were further analysed, pupils' self-concepts emerged to be contributing most towards achievement in Mathematics. Thus the null-hypothesis is rejected with regard to pupil variables.

Problem Statement 3

In keeping with previous research, this study established that male pupils achieved better at Mathematics than their female counterparts. This difference, however, is not significant since the probability is greater than 0.05. Therefore, the null-hypothesis may not be rejected.

Problem Statement 4

Results from this study suggest that children from diverse socio-economic backgrounds did not differ significantly with regard to Mathematics achievement on the 5%-level of significance. Hence, the null-hypothesis cannot be rejected.

Problem Statement 5

This research found that pupils with female teachers achieved better at Mathematics than pupils with male teachers. This difference was not significant however, since $p > 0.05$. Therefore, the null-hypothesis cannot be rejected.

Problem Statement 6

According to the empirical research results the Mathematics achievements of pupils taught by teachers with diverse qualifications did not differ significantly on the 5%-level of significance. Consequently, the null-hypothesis may not be rejected.

Problem Statement 7

The empirical research established no significant difference on the 5%-level of significance between Mathematics achievements of children taught by teachers with diverse levels of experience. Hence the null-hypothesis cannot be rejected.

Problem Statement 8

The empirical research did not find significant differences between the Mathematics achievements of children taught by teachers with diverse levels of in-service education on the 5%-level of significance. The null-hypothesis may therefore not be rejected.

Problem Statement 9

It was found in this study that pupils who had more homework to do (daily, four times per week, or thrice per week) achieved better than pupils who had less homework to do (never, once per week or twice per week). However, the difference was not significant and the null-hypothesis is not rejected.

Problem Statement 10

According to this empirical research, pupils who wrote less tests (not more than once per term) achieved significantly better than pupils who wrote tests more frequently (weekly, every two weeks or once per month). The null-hypothesis is therefore rejected on the 5%-level of significance.

6.2.3 Final Conclusions from Both the Literature Study and the Empirical Research

Problem Statement 1

Both this study and previous research established a significant correlation between diverse variables and Mathematics achievements of pupils. Of variables such as

the teacher, home environment, peer group and pupil variables, it is worth to note that pupil variables correlate highest with achievement in Mathematics.

Problem Statement 2

The literature review identified peer group variables as contributing significantly to achievement in Mathematics of adolescents. This study, however, found pupil variables to contribute significantly towards the variance in Mathematics achievement. In accordance, the correlation between pupil variables and Mathematics achievements was the highest ($r = 0.24$) and thereafter peer group variables with achievement in Mathematics. This may be attributed to the change in social patterns of adolescents, who are influenced less by parent and teacher variables and more by peer group variables. Of interest is the observation that the pupil's self-concept contributed significantly towards achievement in Mathematics. Important others like peers may play a significant role in enhancing the pupil's self-concept. Thus, peer group variables may influence pupil variables such as self-concept. Thus these two variables are related and may both influence Mathematics achievement.

Problem Statement 3

In general it would seem as if there is a trend for male adolescents to achieve significantly better at Mathematics than female adolescents. However, this was not confirmed by this study.

Problem Statement 4

Though not confirmed by this study, there is a trend that children from higher socio-economic backgrounds achieve significantly better at Mathematics than children from lower socio-economic backgrounds.

Problem Statement 5

Although not confirmed by the empirical research, girls may achieve significantly better at Mathematics when taught by a female teacher. The female teacher acts as a role model to girls and hence eradicate their deep-rooted belief that Mathematics is a masculine subject.

Problem Statement 6

Although not confirmed by this study, research suggests that pupils taught by well qualified teachers may do significantly better at Mathematics than those taught by

poorly qualified teachers. Contrary to this finding however, Maqsd and Khalique (1991:379) found that in spite of the availability of better qualified Mathematics teachers; pupils achieve poorly in the Bophuthatswana (now part of the North-West Province) schools. Most colleges of education concentrate on methodology throughout their period of teacher education; only revisiting the subject content that prospective teachers have already done in the high school. Advanced subject content may enhance teacher confidence in the subject whereas methodology prepares the teacher well for meaningful presentation of subject content.

Problem Statement 7

Although not confirmed by the empirical research, there is a trend that pupils taught by more experienced teachers score significantly higher than pupils taught by less experienced teachers. This may be attributed to the fact that experienced teachers may be able to use different teaching methods to enable pupils of diverse abilities to follow their lessons.

Problem Statement 8

Even though this study did not confirm it, the following trend was revealed by research: Pupils taught by teachers

with more in-service education achieve significantly better than those taught by teachers with less in-service education. Teachers who attend in-service education seminars and workshops keep abreast with new developments in methodology as well as content, and hence are able to promote learning and achievement in Mathematics better than those who do not undergo in-service courses.

Problem Statement 9

Results regarding the relationship between the amount of homework done and achievement in Mathematics, are inconclusive. In support of previous research by Cobb et al (1990:170), this study could not find a significant difference in Mathematics achievements between pupils who do more homework and those who do less homework. Mullis (1991:351) associated low achievements in Mathematics with more frequent homework.

The beneficial part of doing more homework is that it gives pupils time to practise and revise work done in class and hence enhance learning and achievements in Mathematics. However, it may also impede learning because if too much homework is given on a daily basis, this may cause a negative attitude towards Mathematics.

Problem Statement 10

Contrary to previous research, this study established a significant difference between the Mathematics achievements of pupils who wrote more tests and the achievements of those who wrote less tests: Pupils who wrote less tests scored significantly higher than those who wrote more tests. This may be attributed to the fact that those who write less tests study free of pressure and anxiety. Test anxiety impair learning and achievement.

6.3 Recommendations

6.3.1 Recommendations on How to Improve Mathematics Education at School

Mathematics plays a pivotal role in the economic upliftment of any country (Smith 1989:219). Therefore, in order for our children to compete with other countries in the economic battles of the twenty-first century, something needs to be done to curb the impact of negative factors identified in this study as related to Mathematics achievement. Here, recommendations on how Mathematics education can be improved are discussed.

6.3.1.1 Recommendations regarding Pupils' Self-concepts

This study found pupil variables to account for 57% of the variance in Mathematics achievement. The significant others like teachers and parents play an important role in shaping most of the pupil variables like self-concept (which further analysis identified as a pupil variable which contributes significantly to pupils' Mathematics achievement).

In order to improve poor self-concepts which result from continuous failure to solve Mathematics problems, teachers need to use co-operative learning strategies in their lessons. Co-operative learning strategies allow problem-solving to continue when an individual member might have encountered an impasse. The peers could also provide external monitoring for individuals in the group. This strategy could be instrumental in establishing a less restrictive social environment in which students are able to pursue various strategies and ideas better. By so doing, the teachers will be using pupils' shift in socialisation patterns to their advantage. Since this method maximises correct problem-solving, both the group's and individual's positive self-concepts are enhanced. Since this strategy creates a less restrictive learning environment, anxiety is also lessened. Mathematical games can help develop positive self-concepts and alleviate

Mathematics anxiety.

Since parents' mathematical self-concepts influence adolescents' mathematical self-concepts, it may therefore be useful to counsel parents about the expectations they hold for their children.

6.3.1.2 Recommendations with regard to Gender

Students, particularly females, should be helped to overcome their own self-defeating attitudes, which inhibit not only their course-taking patterns but their achievement in Mathematics as well. This can be done by encouraging females to view Mathematics as a subject for both males and females and not as a male domain (as documented by literature).

In order to change the prevailing situation where gender stereotypes are rife, different measures already developed and used in other countries should be introduced into the South African schools. These measures can include: To invite women who work in Mathematics-related professions to participate in discussions about their work. This could provide role models for the girls to identify with. Also offer courses in which, besides the mathematical content, the purpose and role of Mathematics for a career and in society is discussed. The importance of Mathematics for a

career and in society could also be emphasised through teaching materials as well as extra-curricular activities. This will enhance positive attitudes towards Mathematics and enable pupils of both sexes to realise the usefulness of Mathematics. This is in accordance with recommendations by Kaiser-Messmer (1993:228).

Hensel (1989:651-652) quoted Cain and made mention of a number of suggestions that can help teachers (and parents) create an equitable environment and foster the next generation of mathematicians - female and male, namely:

- (1) Take stock of your own attitudes and actions. We define children and our expectations of them in part by the tasks we give them to do.
- (2) Assign classroom and household chores to children equitably. Do not leave all the domestic and clerical chores to females while serving the muscle tasks and leadership roles for males.
- (3) Watch your language. Children do not understand the generic meaning of the word 'man' as referring to men and women. You can revise children's concepts of what males and females can do if you make a habit of using nonsexist words and if you, by example, teach your children to use them.

- (4) Encourage boys and girls to play together in a variety of both active and quiet play ... Artificial separation of the sexes (which is often practised at schools) contributes to the alienation boys and girls - and later men and women - may feel from each other and to the poor communications brought by isolation from others.
- (5) Check Mathematics and reading texts for sex biases. If possible, select unbiased text materials; however, if you must use sexist textbooks, use them to help children develop analytical thought skills by discussing the sexist portrayals in the text and their implications.
- (6) When teaching mathematical concepts to young children try a variety of occupations. Encourage girls to participate in vigorous, active play and encourage boys to perform domestic activities.
- (7) Emphasise non-stereotyped roles in creating and using mathematical word problems.
- (8) Provide children with role models of females who have excelled in Mathematics and science by arranging visits from female mathematicians and scientists and

by encouraging the children to read biographies of women mathematicians and scientists.

- (9) Provide career education for children. The most important objective of career education should be to eliminate sex-role stereotypes which now confine them and to show that each does have choices and possibilities. The new government of the free South Africa expect schools to offer opportunity. Free people have choices, free children should know that they can make choices irrespective of gender.

Excursions to the workplaces of Mathematics-related professionals (of both sexes) could be undertaken so that girls can see these role models and identify with them.

More females need to be encouraged to enrol for teacher education with Mathematics as their major subject to have more teacher role models in class.

6.3.1.3 Recommendations regarding Pupils' Socio-economic Background

To help ensure uniformity in teacher and parent behaviour towards Mathematics, Norman (1988:409) suggested that there be efforts to strengthen ties between school and home especially in low socio-economic areas. The school

can do this by encouraging parents to encourage their children in their Mathematics problem solving. Workshops for parents need to be organised where psychologists and other education experts can alert them of their influence in shaping their children's self-concepts, attitudes and aspirations in relation to Mathematics.

Smith and Gessler (1989:34) suggested that for disadvantaged pupils whose parents cannot guide their children in their educational decision-making process and who may lack role models, science teachers may be the best source of information on careers in technology. This can be accomplished by setting up libraries with appropriate reading materials.

6.3.1.4 Recommendations with regard to the Teacher

* Teaching Methods

Results regarding the probable influence of homework, are inconclusive. However, it seems reasonable to suggest that homework be given regularly (for example daily), but the amount of homework should not be too much to cause negative attitudes. Therefore, homework need to be assigned on topics recently reviewed or introduced and to use such homework for diagnosis and planning. This will enable teachers to identify problem areas in what has been

taught. They will as such be able to devise intervention strategies (programmes).

Hawkey (Mudeliar 1987:46) provided the following methods for the teacher to reduce Mathematics anxiety: (1) pupils should be given guidance on self-control techniques for managing stress, e.g. relaxation skills, increasing self confidence and belief in oneself; (2) anxiety management training programmes could be introduced into schools and would focus not only on Mathematics but on coping with anxiety and stress; and (3) remedial courses could be arranged regularly to enable pupils to update their work.

Furthermore, the atmosphere in class must be conducive for the learning of Mathematics. More use of concrete materials (manipulatives) and calculators will create an interesting and enjoyable atmosphere for learning Mathematics and hence enhance achievement.

Peer teaching and team teaching must be encouraged. General workshops and conferences for pupils may even be arranged. These workshops should target on conveying the message of the importance of Mathematics in the development of a country. In order to provide role models for both sexes, guest speakers need to include

Mathematics-related professionals of both sexes.

The findings of this study associated less test writing with better achievement. Test anxiety may interfere with the performance of those who write tests more frequently (weekly, every two weeks or once per month). Given this result, Mathematics teachers should be encouraged to give a test or two per quarter instead of a series of tests which may have a negative emotional impact on pupils.

Methods should also take gender issues into consideration. Examples given in class must be free of gender stereotypes such as reference to males in most Mathematics examples. Textbooks need to be written in such a way that they give a picture of equity in their reference to males and females.

* Teacher's Qualifications

Results regarding the influence of teacher's qualifications are inconclusive. However, in order to help pupils benefit from better qualified teachers, it is suggested that poorly qualified teachers should be encouraged to enrol for advanced Mathematics content. The prevailing tendency of teachers taking degree majors for which they are not professionally qualified to teach should be brought to a halt. Teachers should instead

further their studies in subjects they are qualified to teach.

Teacher education programmes should prepare Mathematics teachers, with both advanced content and methodology given equal treatment.

* Teachers' Experience

Schools may avoid depriving pupils of the expertise of more experienced teachers by using team teaching. This can be done by having more experienced and less experienced teachers dividing sections in Mathematics amongst themselves in a particular standard (grade). Where for example, teacher A teaches Algebra, teacher B offers Geometry, Teacher C teaches Analytic Geometry and teacher D teaches Differentiation, the influence of teaching experience can be alleviated if these teachers are of diverse experiences. Teachers can rotate on a yearly basis, so that each teacher gets a chance to offer each section.

* In-service Education for Teachers

Advisory Offices should attend both national and international conferences and workshops on new developments in Mathematics education. This will keep them

abreast of new developments in this subject. This will also make in-service programmes worth attending for teachers. A minimum of two in-service education programmes could be scheduled quarterly in a year in order for Subject Advisors to share what they gained from seminars, conferences, and workshops with teachers in their areas of jurisdiction.

Another thing that may be demotivating to teachers is that they are not regarded as contributing partners in in-service programmes. Instead, they attend these programmes to 'receive' new findings on Mathematics education. Advisory Offices can, therefore, encourage teachers to conduct classroom based research on how to improve Mathematics teaching and learning. Teachers should be given time to give reports on their research findings during in-service education sessions. Subject Advisors can even motivate the formation of In-service Education Committees wherein teachers are also represented. These committees will enable teachers to have a say in decision-making processes regarding topics to be covered in a programme, dates for in-service education programmes and other matters pertaining to Mathematics in-service education in their areas. These committees may even be represented in the afore-mentioned conferences and workshops, so that teachers in the committees can work as a team with Advisory Offices in running in-service

education programmes.

6.3.2 Recommendations for Future Research

- (1) Further research should also replicate this study with a larger sample of respondents to determine if significant differences are found in the relevant cases.
- (2) Future research should examine ways in which pupil variables that were identified to have an impact on Mathematics achievement could be improved. More research should be done on ways to develop positive self-concepts in pupils.
- (3) It is also recommended that more research should be conducted to determine the effects of amount of homework and tests on the achievements of pupils in Mathematics.
- (4) This study also associated better Mathematics achievement with female teachers. Therefore, future research should also look into how teacher gender affects achievement in Mathematics.
- (5) This study had a questionnaire as the only data collecting instrument. Another recommendation is to

use qualitative techniques such as interviews and observation, to attempt to validate some of the findings suggested here.

Information from these studies could be fundamental to the development of programmes to improve student Mathematics achievement of both sexes.

6.4 Limitations of the Research

One limitation of the present study was the small sample size. This may have accounted for the lack of significance of differences established in this research.

Secondly, the main data collecting instrument in this study was a questionnaire. The relationship between certain variables and achievement in Mathematics may be better understood if qualitative methods are also employed.

6.5 Final Word

The researcher's wish for all Mathematics teachers is a wish for success in your teaching. Your students depend on your success. We all depend on you. Our country's economic

and technological advancement depend on you.

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APPENDIX A

QUESTIONNAIRE

Hi, there! This is not a test but a questionnaire for which you have all the answers.

- (a) Please do not write anything on this questionnaire.
Write only on the response page provided.
- (b) Do not write above the red line - this is for office use only. Start below the red line next to number 1.
- (c) For each item indicate your answer by means of a single stroke with an HB pencil or black pen on the appropriate number:
[1]; [2]; [3]; [4]; [5]; [6]; [7] or [8].
- (d) Please make sure that the number on the questionnaire is the same as the number on the answer sheet.
- (e) Sometimes only two alternatives are given from which to choose but sometimes more. Please ignore the numbers you do not need.

1. In Mathematics examinations/tests I usually score:

0 - 19%	[1]
20 - 39%	[2]
40 - 59%	[3]
60 - 79%	[4]
80% or above	[5]

2. Gender : Male [1]

Female [2]

3. Age : 17 years or less [1]

18 years [2]

19 years [3]

20 years [4]

21 years [5]

22 years [6]

23 years [7]

24 years and older [8]

4. Father's occupation:

None [1]

Gardener [2]

Security officer/Driver/Mechanic [3]

Police man [4]

Teacher [5]

Lecturer/Manager/Business man [6]

Doctor/Professor/Lawyer	[7]
Other	[8]

5. Mother's occupation:

None	[1]
House-maid/Garden-maid	[2]
Cleaner/Cook	[3]
Typist/Secretary/Nurse	[4]
Teacher	[5]
Lecturer/Manager/Business woman	[6]
Doctor/Professor/Lawyer	[7]
Other	[8]

6. Father's education:

None	[1]
Grade 1 - Std 5	[2]
Std 6 - 8	[3]
Std 9 - 10 or Std 8 and diploma	[4]
Std 10 and diploma or degree	[5]

7. Mother's education:

None	[1]
Grade 1 - Std 5	[2]
Std 6 - 8	[3]
Std 9 - 10 or Std 8 and diploma	[4]
Std 10 and diploma or degree	[5]

8. Monthly income of father:

None	[1]
R1 - R999	[2]
R1000 - R2 999	[3]
R3000 - R6 999	[4]
R7000 and above	[5]
I don't know	[6]

9. Monthly income of mother:

None	[1]
R1 - R999	[2]
R1000 - R2 999	[3]
R3000 - R6 999	[4]
R7000 and above	[5]
I don't know	[6]

10. Number of members in the family (yourself included):

1 - 3	[1]
4	[2]
5	[3]
6	[4]
7	[5]
8	[6]
9	[7]
10 and more	[8]

11. We write Mathematics tests:

Never	[1]
Quarterly (Once per term)	[2]
Monthly	[3]
Fortnightly (Every two weeks)	[4]
Weekly	[5]

12. Our Mathematics teacher gives us homework

Never	[1]
Once per week	[2]
Twice per week	[3]
Thrice per week	[4]
Four times per week	[5]
Daily	[6]

13. Number of reading materials (e.g. magazines,
Mathematics books, newspapers, etc.) at home:

5 or less	[1]
10	[2]
20	[3]
25 and more	[4]

14. My teacher's education:

Std 10 with Mathematics	[1]
Std 10 and degree	[2]
Std 10 and diploma with Mathematics	[3]
Std 10, degree in Mathematics and a diploma	

with Mathematics	[4]
Postgraduate degree in Mathematics and a diploma	[5]
I don't know	[6]

15. My teacher's experience:

No experience	[1]
1 - 4 years	[2]
5 - 8 years	[3]
9 - 12 years	[4]
13 - 16 years	[5]
17 years and more	[6]
I don't know	[7]

16. My teacher's involvement in in-service education:

Never	[1]
1 - 4 times per year	[2]
5 - 8 times per year	[3]
9 times or more	[4]
I don't know	[5]

17. My teacher's gender:

Male	[1]
Female	[2]

Directions for the rest of the questionnaire

- (a). The rest of the questionnaire contains statements on how you feel about the activities in your Mathematics learning (in class and at home). There are no right or wrong answers. Your opinion is what is wanted.
- (b). Think about how well each statement describes your feelings, your parents, your teacher and your friends about Mathematics. Indicate your answer by means of a dash in the appropriate number in the square on the answer sheet provided.
- (c). The numbers have the following meanings:
 - 5 = Strongly Agree
 - 4 = Agree
 - 3 = Undecided
 - 2 = Disagree
 - 1 = Strongly Disagree
- (d). Provide your choice to each statement truthfully.
- (e). Make sure that you indicate your answer in the space next to the same number as that of the question.

(f). Do not write down your name on the answer sheet.

(g). Thank you for your co-operation.

-----+	-----+	-----+	-----+	-----+
Strongly	Agree	Undecided	Disagree	Strongly
Agree				Disagree
(5)	(4)	(3)	(2)	(1)
-----+	-----+	-----+	-----+	-----+

18. I cannot do Mathematics.
19. Our teacher enjoys teaching Mathematics.
20. My Mathematics teacher enjoys talking to us.
21. My Mathematics teacher expects me to make good grades.
22. My Mathematics teacher expects boys to perform better than girls.
23. My Mathematics teacher expects boys and girls to perform equally well.
24. Female mathematicians are as competent as male mathematicians.
25. I easily go to my teacher for help regarding Mathematics problem solving.
26. My Mathematics teacher is unable to answer our questions.
27. My Mathematics teacher knows a lot about Mathematics.
28. My Mathematics teacher is confident about his/her knowledge of Mathematics.
29. My Mathematics teacher let us work in groups during problem solving activities.

+-----+-----+-----+-----+-----+				
Strongly	Agree	Undecided	Disagree	Strongly
Agree				Disagree
(5)	(4)	(3)	(2)	(1)
+-----+-----+-----+-----+-----+				

30. My Mathematics teacher discourages discussion/debate during Mathematics class.
31. We often write notes from the board during Mathematics lessons.
32. My Mathematics teacher explains the meaning of new concepts we learn in Mathematics very well.
33. My mother thinks Mathematics is a waste of time.
34. My Mathematics teacher generally uses teaching aids/media e.g. protractor, pair of compass, ruler, etc during Mathematics lessons.
35. Our Mathematics classes usually consist of lectures.
36. My Mathematics teacher teaches us everything in our syllabus before we write tests or examinations.
37. My Mathematics teacher often commits mistakes while teaching Mathematics.
38. My Mathematics teacher is unfair towards students.
39. My Mathematics teacher explains how Mathematics is relevant to our lives.
40. My Mathematics teacher has a dull personality.

Strongly	Agree	Undecided	Disagree	Strongly
Agree				Disagree
(5)	(4)	(3)	(2)	(1)

START THE NEXT COLUMN ON THE RESPONSE PAGE

41. My Mathematics teacher gets impatient when pupils ask for help.
42. My Mathematics teacher has no sense of humour.
43. My Mathematics teacher always encourages us to work hard in Mathematics.
44. My Mathematics teacher is a pleasant teacher.
45. My father or mother helps me with Mathematics homework.
46. My father or mother is interested in Mathematics.
47. My father or mother is bored by Mathematics.
48. I have no books on Mathematics at home.
49. My parents expect me to do well in Mathematics.
50. My parents encourage me to use a calculator during Mathematics problem solving.
51. My parents always talk about how difficult Mathematics is when I approach them for help.

+-----+-----+-----+-----+-----+				
Strongly	Agree	Undecided	Disagree	Strongly
Agree				Disagree
(5)	(4)	(3)	(2)	(1)
+-----+-----+-----+-----+-----+				

52. My parents enjoy talking to me about Mathematics.
53. My parents encourage me to work hard in Mathematics.
54. My parents are interested in my Mathematics achievements.
55. My parents expect me to attain good marks in Mathematics.
56. My parents expect me to attain qualifications for which Mathematics is a prerequisite.
57. My parents buy me everything necessary for my Mathematics study e.g. textbooks, study guides, calculator, etc.
58. My parents often express their dislike of Mathematics.
59. My parents regard Mathematics as a subject for males.
60. My friends are interested in Mathematics.
61. My friends work hard at Mathematics.
62. My friends are bored by Mathematics.
63. My friends enjoy Mathematics.
64. My best friends do well in Mathematics.

+-----+-----+-----+-----+-----+				
Strongly	Agree	Undecided	Disagree	Strongly
Agree				Disagree
(5)	(4)	(3)	(2)	(1)
+-----+-----+-----+-----+-----+				

65. My friends are not interested in careers related to Mathematics.
66. My friends find Mathematics difficult.
67. My friends do not enjoy any activities related to Mathematics.
68. My best friends and I work together to solve mathematical problems.
69. My friends view Mathematics as more important for boys than for girls.
70. My friends believe that Mathematics is equally important for both boys and girls.
71. My friends believe that boys are better at Mathematics than girls.
72. My friends believe that boys and girls can perform equally well in Mathematics.
73. My friends encourage me to work hard in Mathematics.
74. My friends disapprove of doing well in Mathematics.
75. My friends lend me Mathematics materials that I do not have.

+-----+-----+-----+-----+-----+				
Strongly	Agree	Undecided	Disagree	Strongly
Agree				Disagree
(5)	(4)	(3)	(2)	(1)
+-----+-----+-----+-----+-----+				

76. My close friends intend to follow careers for which they need Mathematics.
77. My friends want to learn more about Mathematics.
78. My friends like Mathematics.
79. My friends say that Mathematics is useful.
80. Mathematics is a pre-requisite for my future career.

START THE NEXT COLUMN ON THE RESPONSE PAGE

81. I find Mathematics difficult.
82. I am good at Mathematics.
83. I would enjoy a career where I use Mathematics.
84. I dislike Mathematics.
85. I feel uneasy in Mathematics class.
86. I feel tense during Mathematics class.
87. Only males should choose careers which need Mathematics.
88. I want to learn more about Mathematics.

+-----+-----+-----+-----+-----+				
Strongly	Agree	Undecided	Disagree	Strongly
Agree				Disagree
(5)	(4)	(3)	(2)	(1)
+-----+-----+-----+-----+-----+				

89. I like using a calculator when solving Mathematics problems.
90. I dislike using a calculator in Mathematics.
91. I always expect myself to do well in Mathematics.
92. We learn important things in Mathematics.
93. I think Mathematics is more important for boys than for girls.
94. I give enough time to studying Mathematics well.
95. I like our Mathematics teacher.
96. I enjoy the way our Mathematics teacher teaches us.
97. My parents always talk about how difficult Mathematics is.
98. My parents always seem afraid of Mathematics when I ask them for help.
99. I feel worried in the Mathematics class.
100. I find it difficult to concentrate on Mathematics tasks.

APPENDIX B

SUMMARY OF THE QUESTIONNAIRE INDICATING EACH VARIABLE

<u>Item number</u>	<u>Variable</u>	<u>Scoring direction</u>
19,20,21,23,43	Teachers' attitudes	+ve
22,38,41	"	-ve
27,28,32,36,39	Teachers' competence	+ve
26,37	"	-ve
29,34	Teachers' methods	+ve
30,31,35	"	-ve
25,44	Teachers' personality	+ve
40,42	"	-ve
46,49,50,52,53,	Parental attitude	+ve
54,55,56,57	"	+ve
33,47,48,58,59	"	-ve
45	Parental self-concept	+ve
51,97,98	"	-ve
60,61,63,64,68,	Peer groups' attitude	+ve
70,72,73,75,76,	"	+ve
77,78,79	"	+ve
62,65,66,67,69,	"	-ve
71,74	"	-ve
80,82	Pupils' self-concept	+ve
18,81	"	-ve
24,83,88,91,95,	Pupils' attitudes	+ve
96	"	+ve
84,85,86,87,92,	"	-ve
93,99,100	"	-ve
89,94	Pupils' study methods	+ve
90	"	-ve

	<u>Positive</u>	<u>Negative</u>
Teachers' attitude	5	3
Teachers' competence	5	2
Teachers' methods	2	3
Teachers' personality	2	2
Parental attitude	9	5
Parental self-concept	1	3
Peer group's attitude	13	7
Pupils' self-concept	2	2
Pupils' attitudes	6	8
Pupils' study methods	<u>2</u>	<u>1</u>
	<u>47</u>	<u>36</u>